

Final Report
Calumet Containers Site
Hammond, Indiana

0000006

Prepared by:
Noel C. Krothe
and
Darrell I. Leap
Hydroscience Associates
404 Blue Ridge Drive
Bloomington, IN 47401

October 4, 1988

Prepared for:
Indiana Department of Environmental Management
Debra Chelf, Project Coordinator



HYDROSCIENCE ASSOCIATES, INC.

FINAL REPORT
CALUMET CONTAINER SITE
HAMMOND, INDIANA

Prepared for:

Indiana Department of Environmental Management
Office of Environmental Response
5500 West Bradbury Avenue
Indianapolis, Indiana 46241

Under:

IDEM Contract No. A-305-53

IDEM Project Coordinator:
Debra Chelf

Prepared by:

Noel C. Krothe
Darrell I. Leap

Hydroscience Associates, Inc.
404 Blue Ridge Drive
Bloomington, IN 47401

October 4, 1988

TABLE OF CONTENTS

	Page
List of Tables	i
List of Figures	iii
Section 1.0: Introduction	1
1.1: Location	1
1.2: Potential Impact Areas	1
1.3: Known and/or Suspected Contamination Sources	1
1.4: Climate	5
Section 2.0: Summary of the Hydrogeology	7
2.1: Drainage/Topography	7
2.2: Regional Geology	7
2.3: Local Geology	8
2.4: Surface Water and Possible Routes of Flow from the Site	9
2.5: Ground Water Flow	11
2.6: Design of a Pumping Test for the Calumet Container Site	20
2.7: Well Layout for Pumping Test	20
2.8: Suggested Procedures for Execution of the Pumping Test at Calumet Container Site	22
2.9: Suggested Procedures for Analyzing Pumping Test Data for Determination of Hydraulic Properties	23
2.10: Method of Stallman	23
2.11: Method of Boulton	27
Section 3.0: Summary of Tanker and Roll-off Box Sampling	30
Section 4.0: Summary of Soil Sampling Results	39
Section 5.0: Analysis of Samples from Well Borings	49

References59

Appendix A: Well Logs

List of Tables

Table	Page
2.1: Approximate thicknesses of the Calumet aquifer and clay aquitard, the depth to bedrock and total depth of well for deep wells MW 1, MW 22, and MW 23	9
2.2: Significant dimensions of pumping test wells . . . . .	.25
2.3: Distances and directions of wells in the pumping test cluster from the pumping well . . . . .	.26
3.1: List of chemical constituents detected in liquid waste sample collected from Tanker #1 . . . . .	.32
3.2: List of chemical constituents detected in liquid-solid composite sample collected from Tanker #1 . . . . .	.33
3.3: List of chemical constituents detected in liquid waste sample collected from Tanker #2 . . . . .	.34
3.4: List of chemical constituents detected in liquid-sludge composite waste sample collected from Tanker #2 . . . . .	.35
3.5: List of chemical constituents detected in liquid waste sample collected from Tanker #2 . . . . .	.36
3.6: List of chemical constituents detected in solid waste sample collected from Tanker #3 . . . . .	.37
3.7: List of chemical constituents detected in solid waste sample collected from the roll-off box . . . . .	.38
4.1: Calumet Container Site, summary of soil laboratory analysis results (grid) . . . . .	.40
4.2: Calumet Container Site, summary of soil laboratory analysis results (spot) . . . . .	.41
4.3: Contaminants by sample percentage class, Calumet Site (grid samples) . . . . .	.42
4.4: Calumet Site, changes in selected contaminants with depth . . . . .	.46
4.5: Comparison of heavy metal concentrations in EMS soil samples with other soil sampling results . . . . .	.47
5.1: Moisture content (vol./vol.) . . . . .	.50

5.2:	Hydraulic conductivity (cm/hr) . . . . .	.51
5.3:	Bulk density packed (gm/cc) . . . . .	.52
5.4:	Atterburg Limits . . . . .	.53
5.5:	Particle size analysis . . . . .	.55
5.6:	Cation exchange capacity (meq./100 g) . . . . .	.57

List of Figures

Figure	Page
1.1: Map showing location of Calumet Containers Site	2
1.2: Map showing general layout of the Calumet Containers Site	3
2.1: Map showing location of wells on the Calumet Containers Site	10
2.2: Water table map of sand aquifer on the Calumet Containers Site	12
2.3: Cross section A-A'	13
2.4: Cross section B-B'	14
2.5: Cross section C-C'	15
2.6: Location of cross sections A-A', B-B' and C-C'	16
2.7: Contour map of bedrock surface at the Calumet Containers Site	18
2.8: Bedrock potentiometric map for the Calumet Containers Site	19
3.1: Map showing locations of semi-tankers and roll-off box sampled during Task 4 activities	31
4.1: Location of soil sampling points and field measurements of volatiles	43
4.2: Maximum concentrations of lead and total organics	44

SECTION 1.0

Introduction

A review of background information pertaining to the site has been conducted by Hydrosience. Indiana Department of Environmental Management (IDEM) files were included in this background review. The following synopsis has been prepared.

1.1 Location

The Calumet Containers Site is a triangular tract of land in the northwest quarter of Section 24, Township 37 North, Range 10 West in Lake County (Figure 1.1). The site covers approximately 11 acres, 90 percent of which is in Indiana and 10 percent in Illinois (Figure 1.2). It is bounded on the southeast by the Indiana Harbor Belt Railroad and on the northeast by 136th Street.

1.2 Potential Impact Areas

The Calumet Containers Site lies in a residential and industrial area. A trailer park consisting of 366 house trailers and a housing subdivision containing 34 single family homes is located less than a third of a mile from the site in Indiana. In Illinois, two trailer parks containing 660 and 75 house trailers, respectively, lie within a third of a mile of the site. A channel extension of Wolf Lake lies approximately 100 yards northeast of the site. Powder Horn Lake, a recreation and fishing area, exists approximately 50 yards directly west of the site in Illinois.

1.3 Known and/or Suspected Contamination Sources

The Calumet Containers facility received, stored, cleaned and recycled metal containers ranging in size from five-gallon pails to 55-gallon drums

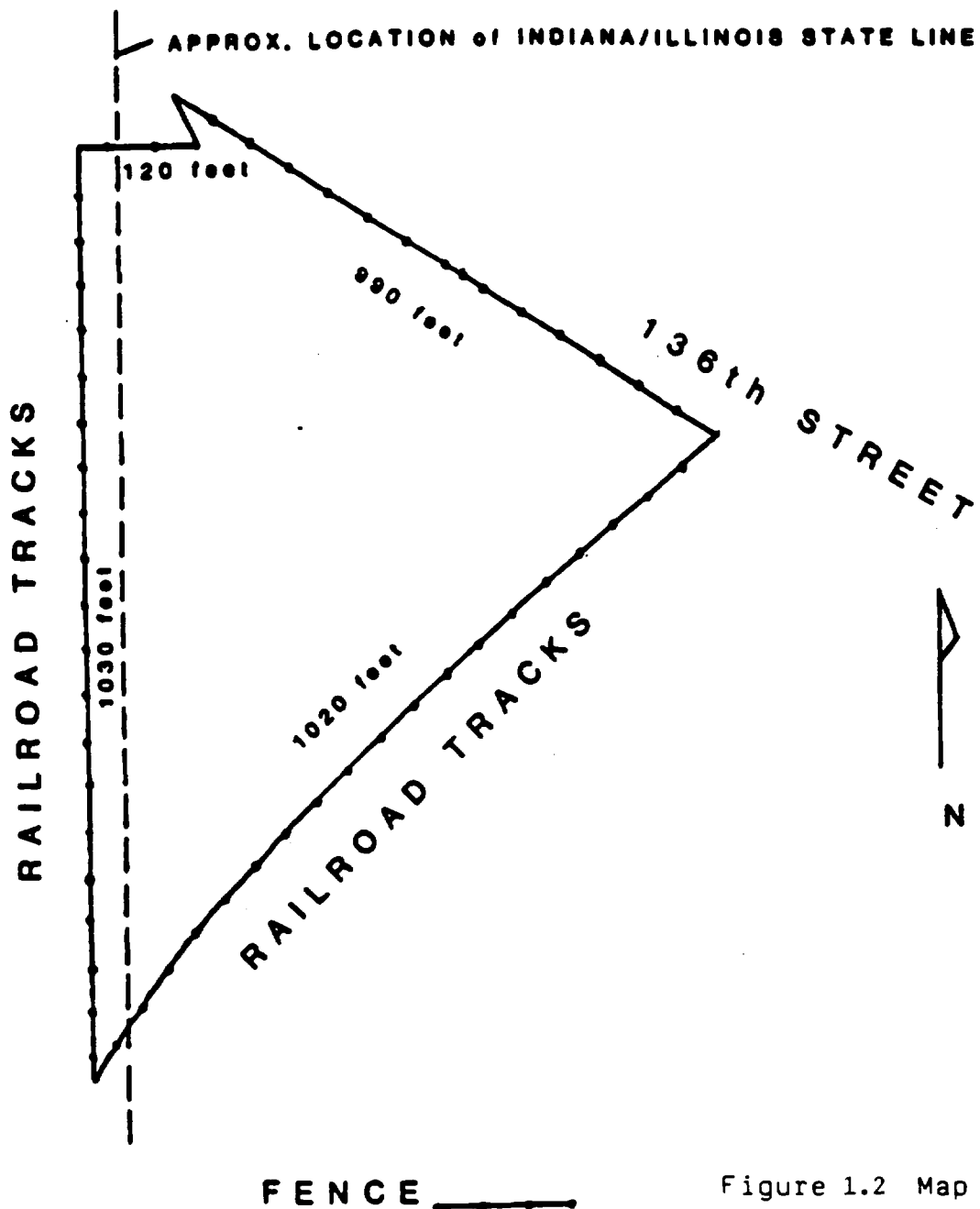


Figure 1.2 Map showing
general layout of
the Calumet Containr
Site

Source: Indiana Departmer
of Environmental
Management

along with various sized fiber drums. The drums originated from paint, ink, and graphic arts industries. The reconditioning operation began in the 1960's and terminated with a fire on April 21, 1982.

On April 26, 1982, 69 truck trailers were observed at the site during a survey of the area by a U.S. EPA Technical Assistance Team. The trailers were found to contain solids and liquids in drum storage as well as liquids in bulk storage in several tank trailers. Drums were believed to contain such materials as aromatic hydrocarbons, xylene, adhesives, and paint waste. Aerial photographs dating back to 1978 show a heavy concentration of drums in the southern portion of the site. Surface water runoff collected and analyzed after the 1982 fire indicated the presence of cyanide, dichloromethane, dichloroethane, trichloroethane, trichloroethylene, methylbenzene, and diamethylbenzene. A 1980 hydrogeological study of the site by the State of Illinois, through a contract with Soil Testing Service, found elevated levels of phenolics, toluene, xylene, heavy metals, and other inorganic constituents in on-site ground-water samples. Analysis of soil samples from three on-site locations taken April 22, 1982, by the Indiana State Board of Health found high levels of arsenic, copper, lead, iron, manganese, and zinc. City of Hammond officials suspected that wastes have been buried on-site during the facility's operational lifetime and believe that such practices have caused the discoloration of on-site soils and ground water.

Immediate removal actions by the U.S. EPA Region V at the site in 1982 removed approximately 5500 gallons of liquid and 30 cubic yards of sludge. Additional clean-up activities were completed by the U.S. EPA in February of 1984.

Preliminary analyses of soil samples from the site by the

Indiana Department of Environmental Management have revealed mercury levels above the recommended action level. During a field reconnaissance by Hydrosience on February 27, 1987, green-colored water was noted in ditches adjacent to the Indiana Harbor Belt Railroad. The color of ponded water on the site was also noted to be green during a Hydrosience field reconnaissance on January 16, 1987.

1.4 Climate

Average monthly temperatures and precipitation rates for Lake County are provided in Table 1.1. This information was compiled from measurements at Whiting, Indiana, spanning a 50-year time period (1910-1961). According to Lou Perdansky, meteorologist with the Indiana Dune National Lakeshore, the information in Table 1.1 is still relatively accurate.

Table 1.1 shows the wettest months of the year for Lake County occur in May and June. The average high temperature for the month of June is 79° while the average temperature for the month of July is 84°.

Table 1.1 Monthly temperature and precipitation at Whiting, Indiana, 1931-1957. (Source: Rosenshein and Hunn, 1968).

Month	Average Temperature High	°F Low	Precipitation (inches)
January	33	18	1.8
February	36	21	1.4
March	46	29	2.6
April	57	39	3.1
May	69	49	4.1
June	79	59	4.0
July	84	65	3.8
August	83	74	3.2
September	76	57	3.0
October	65	46	3.2
November	49	33	2.2
December	36	22	1.8

SECTION 2.0

Summary of the Hydrogeology

2.1 Drainage/Topography

The site occupies a nearly level to slight depressional parcel of land. A small pond, approximately seven (7) feet deep, surrounded by a marsh is located in the northeastern part of the site. The pond is man-made, however, it is undoubtedly ground-water fed. The marsh appears to be natural. Very little surface run-off probably occurs due to the flat nature of the land, detailed discussion of runoff from the site is found in section 2.4. A field reconnaissance by Hydrosience in January revealed large puddles of surface water in the middle portion of the site. Subsequently, it can be assumed that drainage is poor, at least at this portion of the site. Depressional areas of the site received particular attention with regard to soil sampling, as discussed later (Section 4.0).

2.2 Regional Geology

Ninety to 100 feet of glacial material overlies the bedrock in the area of the Calumet Site. A preliminary examination of selected logs of water wells in the Hammond area indicated the existence of a sand deposit extending from near the surface to a depth of 20-25 feet. The sand, commonly referred to as the Calumet Aquifer, is a prime source of ground water with static water levels ranging from 2 to 4 feet below land surface.

Well drillers' descriptions indicate the presence of 5-10 feet of lacustrine clay underlying the sand. The deposits of sand and clay are possibly ancient beach lines and lake bottoms of glacial Lake Chicago. The lacustrine clay apparently grades into a glacial till with depth. The United States Geological Survey (USGS) has conducted regional geologic

studies in the area of the Calumet Container Site. Preliminary work from the USGS indicates that the till extends to bedrock, which occurs at a depth of approximately 100 feet (Shedlock, Personal Communication, 1986). The existence of intertill sand and gravel deposits is a possibility; however, provisional USGS data suggests that such an occurrence is not likely (Shedlock, Personal Communication, 1986). Deposits of sand and gravel within the till would most likely be present only as thin discontinuous lenses.

Bedrock deposits in the area consist of dolomite, cherty limestone, and shale of the Silurian Niagaran Series. It dips southwestward at a rate of five to seven feet per mile.

Two major natural soils are present at the site. The northern one-third of the site is characterized by marsh. Soils covering the southern two-thirds of the site have been mapped as the Oakville-Tawas Complex. The complex consists of fine to medium sand, muck, and loamy sand. These soils are characterized by very rapid permeabilities greater than 1.3×10^{-2} cm/sec (Soil Conservation Service, 1972).

Throughout much of the site the natural soils are covered by fill material that contains mixtures of clay, silt, sand, gravel, slag cinders, and unidentifiable materials. The occurrence of yellow and blue paint sludges was noted in some parts of the site. During clean-up activities conducted on the site by the U.S. EPA, additional fill material consisting of relatively impervious clay was transported to the site. Most of this material is located in the western and southwestern portion of the site.

2.3 Local Geology

Twenty-three wells were drilled on the Calumet Container Site to characterize the surficial and bedrock materials. Corrected logs of the 23

wells are presented in Appendix A. Examination of Figure 2.1 shows the location of the wells.

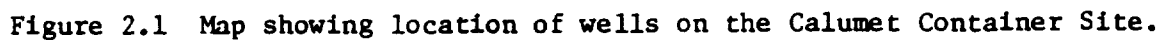
Examination of the drilling logs from MW 1, 22 and 23, which were drilled through the surficial material into bedrock, show a lesser depth to bedrock than the 100 feet suggested by the USGS. The surficial material (Calumet aquifer) has approximate depths of 25 feet, 24 feet, and 21 feet at MW 1, MW 22, and MW 23, respectively (Figure 2.1 and Table 2.1). The thickness of the clay aquitard as observed in drilling between the Calumet aquifer and the carbonate bedrock varies from a maximum of 36.5 feet at MW 1 to a minimum of 9.5 feet at MW 21. The deepest depth to bedrock is 61 feet at MW 1 and the shallowest is 33.5 feet at MW 22, is which approximately 1/3 of the depth estimated for the site prior to drilling. A more thorough discussion of the aquifer and clay thickness can be found in section 2.5.

Table 2.1. Approximate thicknesses of the Calumet aquifer and clay aquitard, the depth to bedrock and total depth of well for deep wells MW 1, MW 22, and MW 23 at the Calumet Container Site (for location see Figure 2.1).

Well #	Thickness of Calumet aquifer (ft)	Thickness of Clay (ft)	Depth of Bedrock (ft)	Total Depth (ft)
MW 1	25	36.5	61	80
MW 22	24	9.5	33.5	50
MW 23	21	21	42	57

2.4 Surface Water and Possible Routes of Flow from the Site

The only perennial body of surface water noted at the site is a man-made pond in the northeast part of the site with a maximum depth of approximately seven feet (Figure 2.1). This pond extends nearby to the site



boundary fence running northwest, southeast along 136th Street. At this spot, the land surface is low enough that during very wet times, the water from the pond could extend outside the fence, thus allowing water to leave the site at this point.

Another possible pathway for escape of surface water from the site is a low spot in the vicinity of Monitoring Wells 20 and 21 at the fence line running northeast, southeast along the railroad (Figure 2.1).

Finally, a third low spot, immediately east of Monitoring Wells 1, 2, and 3 extends under the fence. Surface water has noted to pond between the fence and 136th Street near this cluster of wells (Figure 2.1).

2.5 Ground Water Flow

Two aquifers have been found below the Calumet Container Site. The surficial aquifer (the Calumet Aquifer), consisting mainly of fine, silty sand, covers the entire site from the surface with a minimum thickness of 21 feet at MW 23 and a maximum depth of 25 feet at MW 1.

Water level measurements of the wells finished in this aquifer taken in May 1988 reveal the water table is sloping generally northeasterly with a gradient of approximately 0.002. The highest water table elevation measured at this time was 585.2 feet asl (above sea level) at MW 8 and MW 9. The lowest elevation was found to be 583.0 feet asl at MW 20 (Figure 2.2, marked with an *).

Although the water level in MW 20 stands at 583.0 feet asl, MW 21 just next to it had a water level measuring 583.7 feet asl in May 1988, which is in accordance with the general water table elevation along the entire northwest-southeast length of the site.

The location of three cross sections A-A', B-B' and C-C' (Figures 2.3, 2.4 and 2.5) for the site are shown in Figure 2.6. Cross sections A-A' and

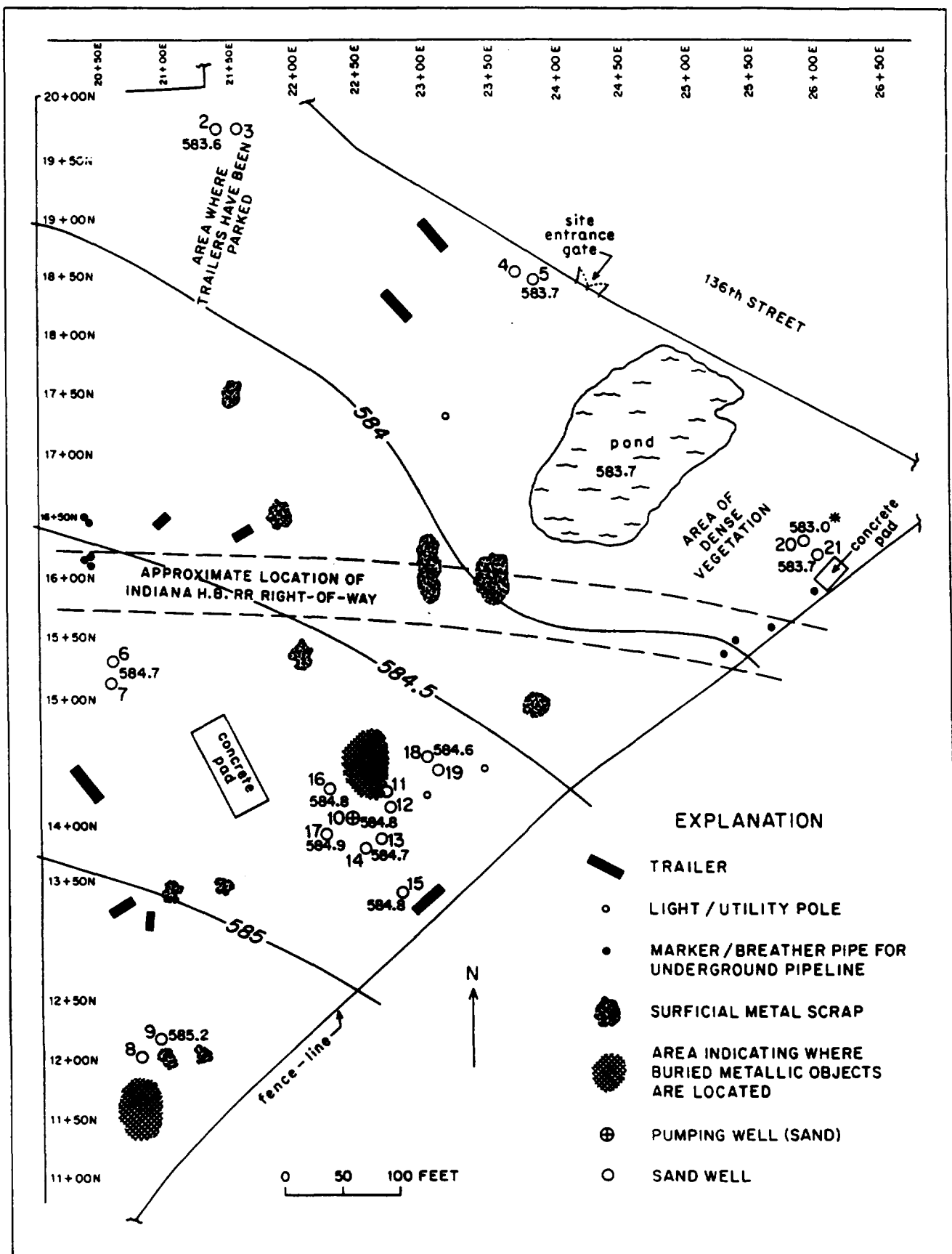


Figure 2.2 Water table map of sand aquifer on the Calumet Container Site.
(For explanation of * at well 20 see Figure 2.3 on page 15.)

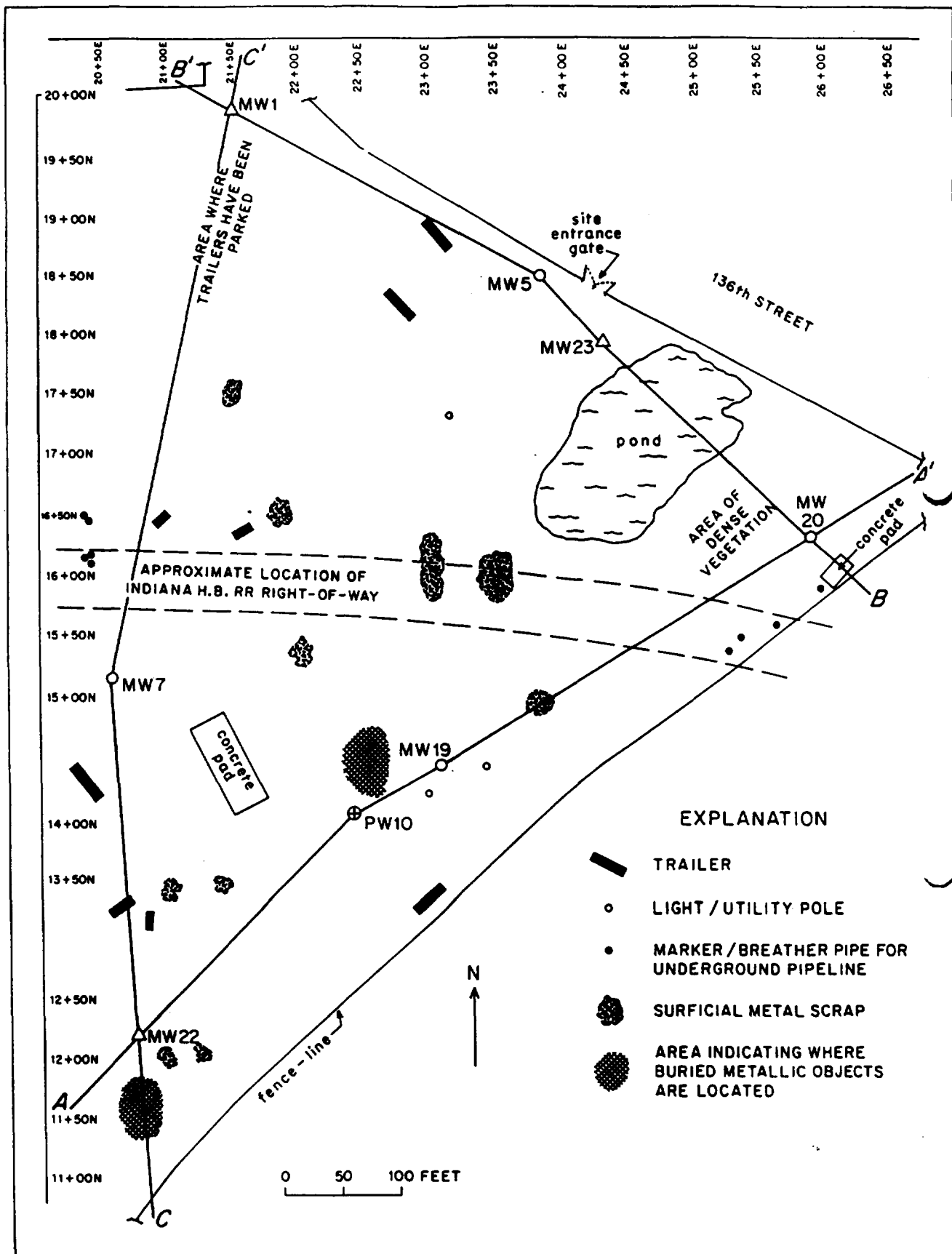


Figure 2.6 Location of cross sections A-A', B-B' and C-C'.

B-B' show that the bedrock rises toward MW 20 and MW 21 and that the clay surface drops and the clay thins drastically at this point to an extrapolated thickness of approximately 0.5 foot or less (Figures 2.3 and 2.4). Therefore, it is possible that water from the sand or surficial aquifer actually enters the bedrock aquifer at this point, thus causing the 0.7 foot head difference between the shallow screened piezometer, MW 21 and the deeply screened piezometer, MW 20. This particular location is the only one found in this study where vertical flow to the bedrock aquifer may be significant. Another explanation for this water level difference is an inaccurate measurement which we feel is unlikely.

The bedrock aquifer is separated from the surficial aquifer over the rest of the site by an aquitard of till and lacustrine clay ranging in thickness of 0.5 foot at MW 20 to 36.5 feet at MW1 (cross section B-B') (Figure 2.4). The actual thickness of this aquifer at the site is unknown because no holes have penetrated it completely at the site and no holes have been found to penetrate the bedrock in the general vicinity.

Stratigraphic information from MW 1, MW 22 and MW 23 indicates that the surface at the bedrock slopes in the direction N38°W with a measured high of 554 feet asl at MW 22 to a measured low of 524 feet asl at MW 1 (Figure 2.7).

The potentiometric surface of the bedrock aquifer trends N35°E with a gradient of 0.006, as found from measurements in MW 1, MW 22, and MW 23 in May 1988 (Figure 2.8).

Thus, the hydraulic gradients of both the bedrock and surficial (Calumet) aquifer trend in the general direction toward the topographically low areas northeast of the site. Throughout the entire Calumet Container Site, the water table in the surficial aquifer remains at approximately

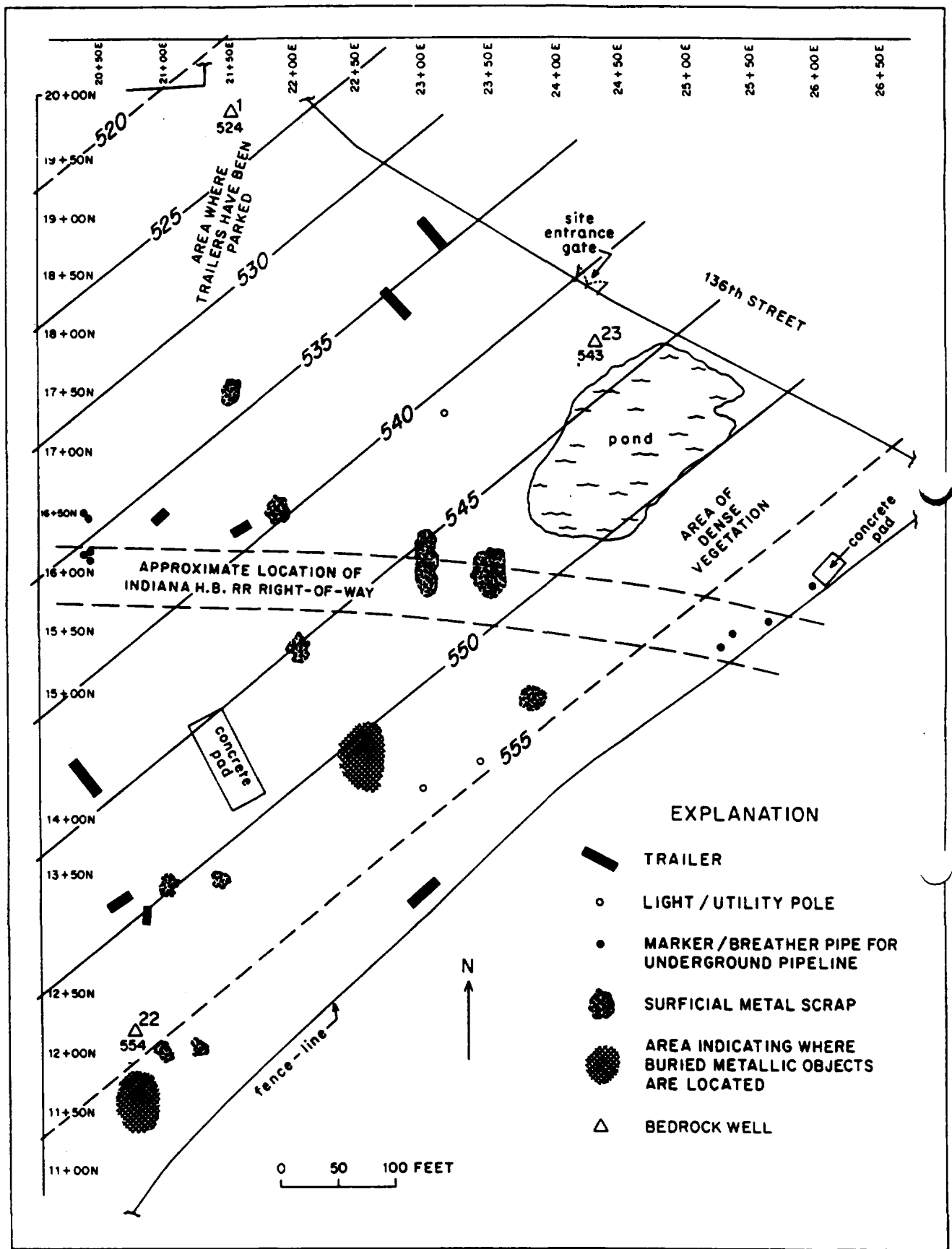


Figure 2.7 Contour map of bedrock surface at the Calumet Container Site.

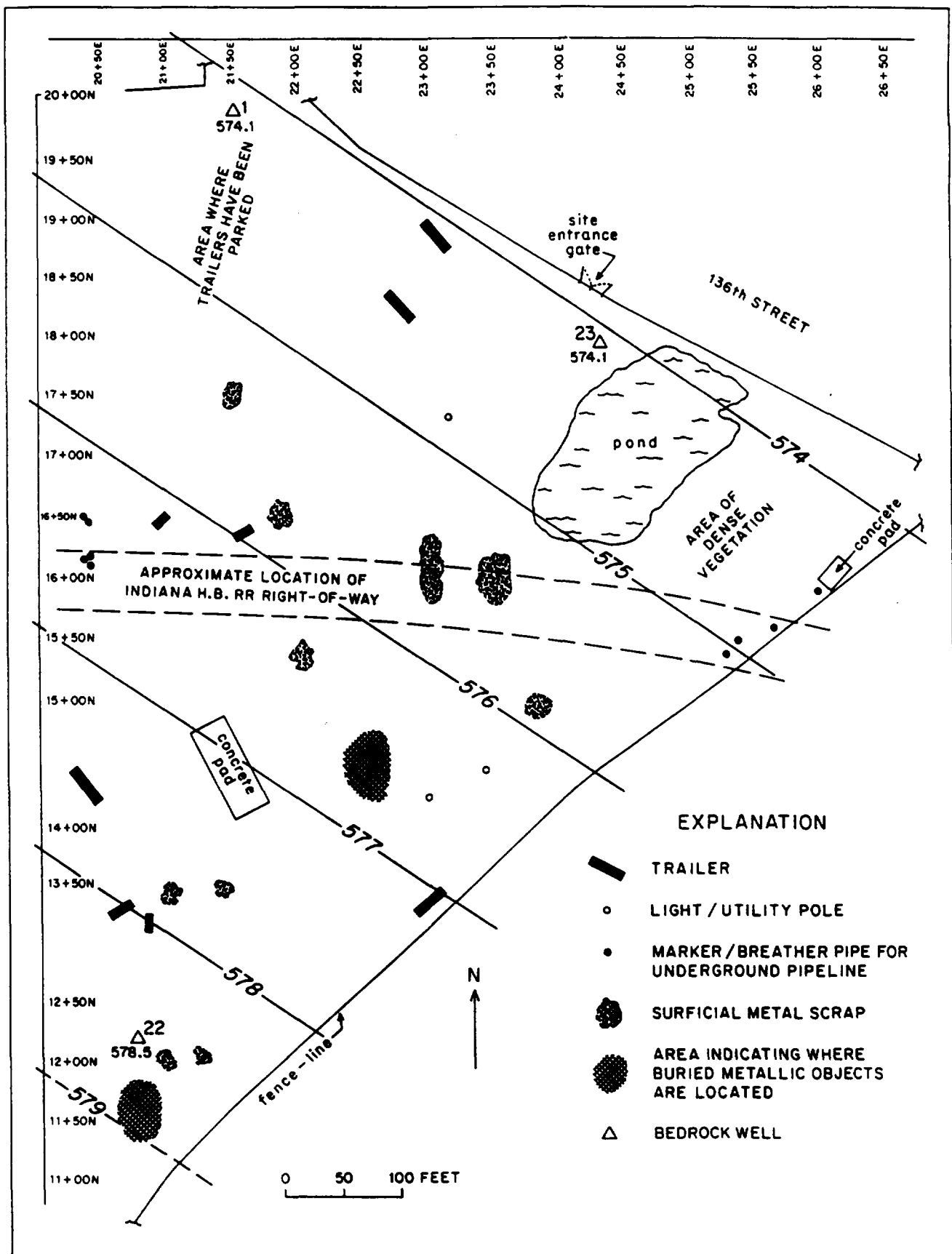


Figure 2.8 Bedrock potentiometric map for the Calumet Container Site.

seven to ten feet above the potentiometric surface of the bedrock. Both surfaces may fluctuate a few feet over the course of a year and from wet to dry periods.

2.6 Design of a Pumping Test for the Calumet Container Site

The surficial (Calumet) sand aquifer covering the site is the primary ground water pathway for contaminants to escape to off-site areas. The aquifer is unconfined, as determined from drilling data, and because of its sedimentary origin, can be expected to show hydraulic anisotropy in the vertical section, i.e., the horizontal hydraulic conductivity can be expected to exceed the vertical hydraulic conductivity.

A pumping test was designed to determine both vertical and horizontal hydraulic conductivity mainly by two well-known and well-documented methods: (1) the Stallman Method (in Lohman, 1972), and (2) the Method of Boulton, also in Lohman (1972), described later.

2.7 Well Layout for Pumping Test

Nine wells are arranged in a cluster around the pumping well (Figure 2.1) and are arranged along two rays emanating from the pumping well (PW10). One ray is in the direction $N55^{\circ}E$, almost parallel with the flow direction in the shallow aquifer. The other ray follows the direction $N32^{\circ}W$, almost at a right angle to the other ray. These directions were chosen in order to determine if the pumping tests would reveal differences in hydraulic conductivity in the two directions.

Although Pumping Well 10 (PW10) and piezometers 11-17 (OW11-OW17) were constructed specifically for the pumping test, it was planned to use MW 18 and MW 19 as additional points for observing drawdown during the pumping test. In addition, monitoring wells finished in the upper aquifer along the periphery of the site can also be used as observation wells if desired

during the pumping test, i.e., Monitoring Wells 2, 3, 4, 5, 6, 7, 8, 9, 20, and 21. However, drawdown at these points might be quite small compared to the drawdown in the cluster, due to their distances from the pumping well.

Although the logs of materials encountered when each well was drilled and the specifics of well construction are shown in the drilling logs, information about each well pertinent to the pumping test is given in the following paragraphs.

The pumping well, P-10, is finished with a fully penetrating four-inch I.D. screen, 20 feet long, through the entire saturated thickness, from 2 feet to 22 feet below the surface. It is gravel-packed and was pump tested in November 1987 for 1 1/2 hours at approximately 14 gpm without dewatering the well. Experience in a similar area off the site in similar materials indicates that 15 gpm is a reasonable pumping rate for a test without excessive drawdown in the pumping well, although the investigator may want to try as much as 20 gpm in a preliminary test.

In the method of Stallman (Lohman, 1972), open end piezometers are positioned at various distances above the aquifer bottom in order to observe variations in hydraulic head in the vertical cross-sectional plane. In Stallman's method the letter Z represents the distance from the bottom of the aquifer to the opening in an open-end piezometer and b is the aquifer thickness. Piezometers are positioned at preselected depths so that the value of Z for each will be some fraction of b.

Open-end piezometers are suitable for coarse-grained, very permeable aquifer materials. In very fine-grained, thixotropic materials comprising the surficial aquifer underlying the Calumet Container Site, an open-end piezometer is not advisable because the piezometer may not drain fast enough during drawdown from pumping, thus giving erroneous drawdown values

at particular times, and there is a very great chance for sand to ooze into the open-end piezometer to cause plugging.

In such materials, short screens surrounded by a filter pack may be used and the distance Z is measured from the aquifer bottom to the center of the screen length.

Two-foot long screens were chosen as an optimum length to allow rapid dewatering of the piezometers during pumping of the pumping well and to still yield a head measurement at almost a point. Screens similar to these have been used in pumping tests in similar lithologies with good results.

The saturated thickness of the aquifer when PW-10 was installed was 20 feet. The water table will be expected to change somewhat during the course of a year and thus the value of Z for each piezometer will change slightly, but not enough to significantly affect the results of the pumping test.

2.8 Suggested Procedures for Execution of the Pumping Test at the Calumet Container Site (In Sequential Order)

1. Transducers should be calibrated while attached to the same channel of the data logger which will be used for that transducer during the pumping test.
2. Transducers should be emplaced in the piezometers far enough below the static water level that drawdown during pumping will not lower the water level below the transducer during the test.
3. The pump should be attached to commercial power at the site with a portable generator for backup.
4. The pumping test equipment (pump, data logger, transducers, etc.) should be tried out on a test run for 2-3 hours in order to check out the

equipment. Different pumping rates should be tried to determine the optimum (probably 10-15 gpm) and the pump discharge valve should be set to that rate.

5. The pump should be shut off and the recovery of the water level recorded until full recovery of the water table.
6. The pump should remain off for 24 hours after recovery to monitor transient changes in the water table in order to determine if these changes are significant enough to extrapolate throughout the pumping testing period.
7. The pumping test should then run for 24 hours with data recorded during the following intervals, each minute for the first 15 minutes, 3 minutes for the next 45, and 15 minute intervals for the duration of the test. Careful monitoring of the pumping rate should be performed.
8. After 24 hours, the pump should be shut off and the recovery should be monitored in the piezometers for a period long enough to witness complete recovery or enough recovery to extrapolate to full recovery. This step is not absolutely necessary, but is suggested as a check.

NOTE: Before and after inserting the pump, piping, transducers and cables into the wells, these items should be suitably decontaminated.

2.9 Suggested Procedures for Analyzing Pumping Test Data for Determination of Hydraulic Parameters

This pumping-test was designed primarily so that the data could be analyzed by the method of Stallman (in Lohman, 1972), and by the method of Boulton, also in Lohman (1972).

2.10 Method of Stallman (in Lohman, 1972)

Perform the following steps with time drawdown data for all piezometers except MW 18 and 19:

1. For each piezometer, plot drawdown from static water level on the

ordinate versus time on the abscissa on double-logarithmic paper.

2. Match this plot to the proper type curve on PLATE 6 in Lohman, 1972.

There are five separate sets of curves on this plate--each set corresponds to a particular value of Z . If $Z = b$ (at the water table) use Set A. If $Z = 0.9b$, use Set B. Set C corresponds to $z = 0.75b$ and Sets D and E correspond to $Z = 0.5b$ and $Z = 0$ (base of aquifer), respectively. Therefore, in order to use these sets, one must know the value of Z for each piezometer (figure from current water table and data in Table 2.2). The aquifer thickness b is actually the saturated thickness which will be expected to change with changing water-table elevation over the course of a year. As a result, the value of Z will also change but the data curve can still be matched to the set of type curves whose " Z " value most closely approximates the " Z " value of the data curve without significant error.

3. After the match is made, pick from the best fit the value of which best approximates the data curve (some interpolation may be necessary).

Table 2.2. Significant dimensions of pumping test wells. (Distances and directions of wells in the test cluster from the pumping well are presented in Table 2.3.

Piezometer	Depth to Screen Bottom (feet)	Screen Length (feet)	Depth of Screen Center (feet)
OW 11	10	2	9
OW 12	7.1	2	6.1
OW 13	10	2	9
OW 14	7	2	6
OW 15	7	2	6
OW 16	21.9	2	20.9
OW 17	22	2	21
OW 18	13.7	11	8.2
OW 19	23	11	17.5

NOTE: Saturated thickness (b) of the aquifer is 20 feet.
Bottom of aquifer = 22.5 feet.

Table 2.3. Distances and directions of wells in the pumping test cluster from the pumping well.

Well	Distance in feet from Pumping Well (P-10)	Direction
------	--	-----------

OW-11	18.8	NE
OW-12	16.0	NE
OW-13	17.9	SE
OW-14	17.7	SE
OW-15	74.5	SE
OW-16	19.8	NW
OW-17	19.3	SW
MW-18	75.0	NE
MW-19	76.0	NE

4. Pick a match point on the type curve such that the values of both Tt/r^2S and $s T/Q$ are equal to 1.0. From this point intersect perpendicular lines to the abscissa and the ordinate of the data curve and pick off values of t and s respectively at the intersection points.
5. Compute transmissivity as

$$T = 1.0 Q/s$$

Storativity as

$$S = Tt/1.0r^2$$

and the ratio of vertical to horizontal hydraulic conductivity as

$$\frac{K_z}{K_r} = (b/r)^2$$

Horizontal hydraulic conductivity can be found as

$$K_r = T/b,$$

and vertical hydraulic conductivity can be found from

$$K_z = (b/r)^2 K_r.$$

2.11 Method of Boulton (in Lohman, 1972)

Boulton's method can be used for analyzing drawdown data from fully-penetrating piezometers and/or from partially-penetrating piezometers which are positioned at a radial distance (r) from the pumping well greater than two times the aquifer thickness. In this case, $r \geq 4b$ feet. This method can be used to determine transmissivity, elastic storativity and specific yield of an unconfined aquifer while taking into account delayed yield from storage which may occur early in a pumping test in an unconfined aquifer. Boulton expresses drawdown as

$$s = \frac{Q}{4T} W(U_{el}, r/B)$$

$$\text{and } U_e = \frac{r^2 S_e}{4Tt}$$

$$U_l = \frac{r^2 S_l}{4Tt}$$

S_e = elastic storativity (early part of test)

S_l = specific yield (later part of test)

T = transmissivity

1. Plot time drawdown data for all piezometers to be considered on double logarithmic paper as before.
2. Match the data to type curves on PLATE 8 in Lohman, 1972, in the following manner:
 - (a) for early time (before and after the data curve begins to flatten, but before it starts to rise again), match the data curve to the leftmost curves (Type A curves),
Interpolate to find the value of r/B that best describes the data curve.

Pick a match point on the type curve set and draw perpendicular to the upper abscissa of the type curves, and the abscissa of the data curve and the ordinates of both type curves and data curves to find values of

$$\frac{1}{u} = \frac{4Tt}{r^2 S_e} \text{ and}$$

$$\frac{4Ts}{Q} = W(u)$$

from the type curves and values of t and values of s from the data curves.

Compute transmissivity by the formula

$$T = \frac{Q}{4s} W(u, r/B)$$

and early-time storativity as

$$S_e = \frac{4TtU}{r^2}$$

If late-time data shows drawdown increasing after seeming to level off, then this late-time data may also be used. In this case the data curve is shifted slightly to the right to match the late-time data with the Type B curves of Boulton. Again, the match is made and the match point is selected exactly as before except the perpendicular is dropped to the lower abscissa of the type-curve set to obtain a value of $1/u = 4Tt/r^2S_1$. Other match values are found as before.

Values of transmissivity and storativity are computed as before except this match gives late-time storativity which might differ considerably from the early-time value. Also, the transmissivity value calculated for late time may be somewhat different from the early-time value.

After installation of wells, they were developed by withdrawing enough water to clean out sand and silt. The following wells were developed by suction pumping: MW-1, MW-22, MW-23, PW-10, OW-11, OW-12, OW-13, OW-14, OW-15, OW-16, OW-17. The remaining wells were developed by bailing at least three casing volumes from the wells.

3.0 Summary of Tanker and Roll-off Box Sampling

A separate report, Results of Tanker and Roll-off Box Sampling, Calumet Containers Site, Hammond, Indiana (November, 1987) presents the detailed results of field observations and procedures and the chemical results of the tanker sampling. This section summarizes the data and major conclusions in this report.

The locations of the three semi-tankers and the roll-off box that were resampled are shown in Figure 3.1. The tankers are identified by the numbers 1-3 and the roll-off box is situated at location 4.

Laboratory analysis of the seven samples was conducted by EMS Laboratories, Inc., Indianapolis, Indiana. Major constituents identified in each of the seven samples are listed in Tables 3.1 through 3.7. Complete laboratory results for each analyzed sample can be found in the previously mentioned report.

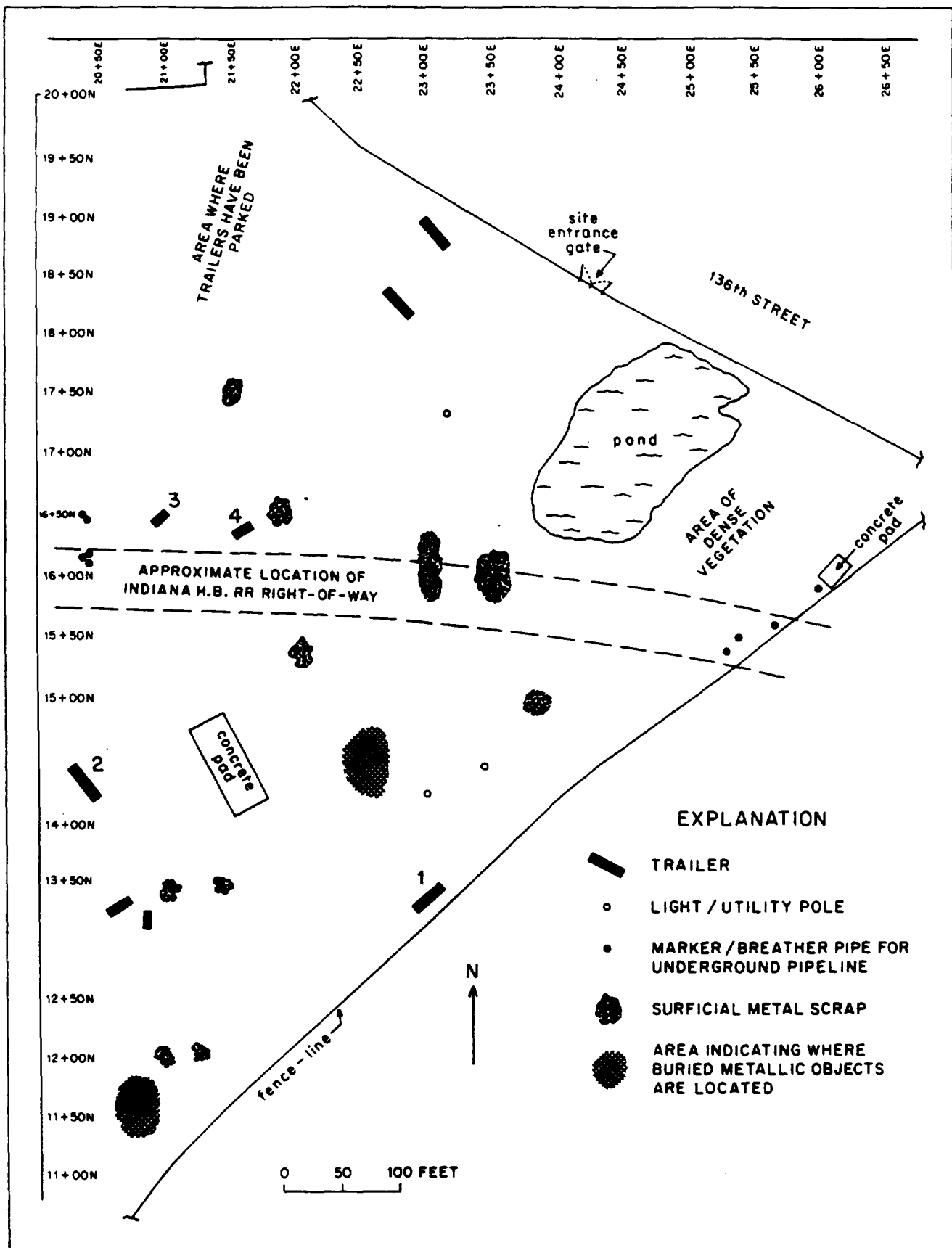


Figure 3.1 Map showing locations of semi-tankers and roll-off box sampled during Task 4 activities.

Table 3.1 List of chemical constituents detected in liquid waste sample collected from Tanker #1.

INORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>Advisory Level (mg/l*)</u>
Cyanide	2.3	NA
Chromium	2.3	5.0
Mercury	.15	0.2

ORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>TLV (ppm)</u>
Phenols	4.2	5.0

Semi-Volatiles

Bis(2-ethylhexyl)phthlate	17,000	NA
4-Chloroaniline	1,100	NL
Fluoranthene	(180)	NL
N-nitroso-diphenyl-amine	640	NL
Di-n-butylphthlate	2.9	NL

* Based on EPA maximum concentration of contaminants for characteristic of EP Toxicity (EPA SW-846, 1986)

() Estimated concentration below detection limit

TLV: Threshold Limit Value

NA: None Available

NL: None located in the literature scanned

Table 3.2 List of chemical constituents detected in liquid-solid composite sample collected from Tanker #1.

INORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>Advisory Level (mg/l*)</u>
Cyanide	1.4	NA
Sulfide	30	NA
Chromium	21	5.0
Mercury	.19	0.2
Lead	10	5
ORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>TLV (ppm)</u>
Phenols	21	5
<u>Semi-Volatiles</u>		
Bis(2-ethylhexyl)phthlate	130,000	NA
4-Chloroaniline	11,000	NL
Di-n-octylphthlate	1,800	NL
Fluoranthene	(990)	NL
Fluorene	(430)	NL
2-Methylnaphthalene	3000	NL
Naphthalene	(670)	10
N-nitroso-diphenyl-amine	8300	NL
Phenanthrene	2000	NA
Pyrene	1100	NL
2,4 Dichlorophenol	(710)	NA
<u>Volatiles</u>		
	<u>Results (ug/l)</u>	
Ethylbenzene	350	100
Toluene	450	100
m-Xylene	600	100
o-Xylene	300	100

* Based on EPA maximum concentration of contaminants for characteristic od EP Toxicity

() Estimated concentration below detection limit

TLV: Threshold Limit Value

NA: None Available

NL: None located in the literature scanned by Hydrosience

Table 3.3 List of chemical constituents detected in liquid waste sample collected from Tanker #2.

INORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>Advisory Level (mg/l*)</u>
Cyanide	48	NA
Chromium	9.3	5.0
Mercury	.16	.20
Nickel	1.8	NA

ORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>TLV (ppm)</u>
Phenols	45	5
<u>Semi-Volatiles</u>	<u>mg/kg</u>	
Bis(2-chloroethyl)ether	260	NL
Bis (2-ethylhexyl)phthalate	1,700	NA
Diethylphthalate	350	5 mg/m ³
Dimethylphthalate	170	NL
2-Chlorophenol	2,600	NL
2,4-Dichlorophenol	99,000	NA
Phenol	19,000**	5
2,4,5-Trichlorophenol	6,100	NL
<u>Volatiles</u>	<u>ug/l</u>	
Acetone	270,000	NL
Benzene	78,000	10
Chloroform	34,000	10
1,1-Dichloroethane	19,000	200
Ethylbenzene	63,000	100
Methylene chloride	400,000	100
Methylisobutylketone	190,000	50
Tetrachloroethane	15,000	50
Toluene	330,000	100
1,1,1-Trichloroethane	16,000	350
Trichloroethane	260,000	50
m-Xylene	160,000	100
o-Xylene	120,000	100

* Based on EPA maximum concentration of contaminants for characteristic of EP Toxicity

** The discrepancy in the phenol concentration may be attributed to either laboratory error or the occurrence of a phenol hotspot within the extracted portion of the sample used for analysis of the semi-volatiles,

TLV: Threshold Limit Value

NA: None Available

NL: None located in the literature scanned by Hydrosience

Table 3.4 List of chemical constituents detected in liquid-sludge composite waste sample collected from Tanker #2.

INORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>Advisory Level (mg/l)*</u>
Cyanide	28	NA
Barium	15	100
Cadmium	3.8	1
Chromium	96	5
Lead	110	5
Mercury	.28	.2
Nickel	3	NA
Selenium	8.5	1

ORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>TLV (ppm)</u>
Phenols	110	5
<u>Semi-Volatiles</u>		
Bis(2-ethylhexyl)phthalate	1500	NA
Diethylphthalate	700	5 mg/m ³
Dimethylphthalate	290	NL
Di-n-butylphthalate	14	NL
Di-n-octylphthalate	22	NL
Fluoranthene	12	NL
Napthalene	20	10
N-nitroso-diphenyl-amine	61	NL
Phenanthrene	14	NA
1,2,4-Trichlorobenzene	21	NL
2,4-Dichlorophenol	1700	NA
Phenol	170	5
<u>Volatiles</u>		
	<u>ug/l</u>	
Acetone	250,000	NL
Benzene	55,000	10
Chloroform	29,300	10
Ethylbenzene	28,000	100
Methylene chloride	310,000	100
Methylisobutylketone	240,000	50
Toluene	160,000	100
1,1,1-Trichlorethane	22,000	350
Trichloroethene	100,000	50
o-Xylene	56,000	100

* Based on EPA maximum concentration of contaminants for characteristic of EP Toxicity

TLV: Threshold Limit Value

NA: None Available

NL: None located in the literature scanned by Hydrosience

Table 3.5 List of chemical constituents detected in liquid waste sample collected from Tanker #2. This sample was a duplicate of Sample #3 (Table 3).

INORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>Advisory Level (mg/l*)</u>
Cyanide	10.5	NA
Chromium	12	5
Mercury	.21	.2
Nickel	3	NA
Selenium	1.6	1

ORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>TLV (ppm)</u>
Phenols	26	5
<u>Semi-Volatiles</u>		
Bis(2-ethylhexyl)phthalate	1600	NA
Diethylphthalate	630	5 mg/m ³
Dimethylphthalate	410	NL
2,4-Dichlorophenol	150,000	NA
Phenol	28,000	5
2,4,5-Trichlorophenol	6000	NL
<u>Volatiles</u>		
Methylene chloride	160,000	100
Methylisobutylketone	89,000	50
Toluene	47,000	100
Trichlorethene	44,000	50

* Based on EPA maximum concentration of contaminants for characteristic of EP Toxicity

TLV: Threshold Limit Value

NA: None Available

NL: None Located in the literature scanned by Hydrosience

Table 3.6 List of chemical constituents detected in solid waste sample collected from Tanker #3.

INORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>Advisory Level (mg/l*)</u>
Cyanide	30	NA
Barium	1000	100
Cadmium	21	1
Chromium	430	5
Lead	16,000	5
Mercury	.44	.2
Nickel	7.8	NA

ORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>TLV (ppm)</u>
Phenols	150	5
<u>Semi-Volatiles</u>		
Di-n-butylphthalate	120	NL
Di-n-octylphthalate	170	NL
Isophorene	5,000	NL
2-Methylnapthalene	360	NL
Napthalene	820	10
2-Methylphenol	(46)	NL
Phenol	(100)	5
<u>Volatiles</u>		
	<u>mg/kg</u>	
Ethylbenzene	5,100	100
Methylene chloride	570	100
Methylisobutylketone	4,900	50
Toluene	13,000	100
m-xylene	9,900	100
o-xylene	6,500	100

* Based EPA maximum concentration of contaminants for characteristic of EP Toxicity

() Estimated concentration below detection limit

TLV: Threshold Limit Value

NA: None Available

NL: None located in the literature scanned by Hydrosience

Table 3.7 List of chemical constituents detected in solid waste sample collected from the roll-off box.

INORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>Advisory Level (mg/l*)</u>
Cyanide	40	NA
Arsenic	1.6	5
Barium	580	100
Cadmium	43	1
Chromium	280	5
Lead	11,000	5
Mercury	3.4	.2
Nickel	43	NA

ORGANICS		
<u>Constituent</u>	<u>Results (mg/kg)</u>	<u>TLV (ppm)</u>
Phenols	32	5
<u>Semi-Volatiles</u>		
Bis(2-ethylhexyl)phthalate	300	NA
Di-n-butylphthalate	(43)	NL
Di-n-octylphthalate	(80)	NL
Isophorene	950	NL
2-Methylnapthalene	110	NL
Napthalene	300	10
Phenanthrene	(40)	NA
<u>Volatiles</u>		
Ethylbenzene	1,300	100
Toluene	1,600	100
m-Xylene	3,100	100
o-Xylene	2,600	100

* Based on EPA maximum concentration of contaminants for characteristic of EP Toxicity

() Estimated concentration below detection limit

TLV: Threshold Limit Value

NA: None Available

NL: None located in the literature scanned by Hydrosience

4.0 Summary of Soil Sampling Results

A separate report, Characterization of Surficial Materials and Soil Sampling Results, Calumet Containers Site, Hammond, Indiana (Final, October 1988) presents the results of field observations and soil sample laboratory results at the site. This section summarizes the data and major conclusions contained in this report.

--Widespread contamination of soil by heavy metals and hazardous organic substances exists throughout the site. All sample locations show some evidence of contamination (see Tables 4.1 and 4.2). A sample is considered contaminated if heavy metals occur in concentrations above normal background levels in northern Indiana, or if organic substances that have been identified as hazardous or potentially hazardous were detected. Lead, cadmium, chromium and cyanide are the most widely occurring inorganic contaminants (see table 4.3). Di-n-butyl phthalate, methylene chloride, methyl ethyl ketone, bis(2-ethylhexyl)phthalate, toluene, m-xylene and o-xylene are the most frequently occurring organic contaminants. Methylene chloride and methyl ethyl ketone occurred in more than three-quarters of the samples, but evidence of contamination of the soil samples in the laboratory prevents any conclusions about how widely they occur at the site.

--The EPA CERCLA clean-up in 1984 removed much of the most highly contaminated soil from the site. However, high levels of lead contamination (greater than 10,000 ppm) remain in the central part of the site, northeast of the CERCLA clean-up zone. Concentrations of lead generally exceed 1,000 ppm in the central and southern areas of the site that lie outside the CERCLA clean-up zone (see Figure 4.1).

--Organic contaminants were detected at all sample locations. The

Table 4.1 Calumet Container Site, Summary of Soil Laboratory Analysis Results (Grid)
(Heavy metals above background and detected organics).

EMS Parameter ID#	Units	Background		Samples Exceeding Background				
		U.S.	No. IN	No.	Average	Maximum	Minimum	% Total
1 Cyanide, total (CN)	mg/kg (ppm)			21	13.8	110	0.5	80.8%
2 Sulfide	mg/kg (ppm)			0	0	0	0	0.0%
3 PH				26	7.6	8	7.1	100.0%
4 Arsenic	mg/kg (ppm)	5.8	6.3	5	34.9	140	7.3	19.2%
5 Barium	mg/kg (ppm)	430	500	5	724	1,200	530	19.2%
6 Cadmium	mg/kg (ppm)	1		17	7.6	20	1.5	65.4%
7 Chromium	mg/kg (ppm)	37	30	14	236	590	34	53.8%
8 Lead	mg/kg (ppm)	16	15	23	2,470	38,000	25	88.5%
9 Mercury	mg/kg (ppm)	0.96	>1.5	1	2.1	2	2.1	3.8%
10 Nickel	mg/kg (ppm)	14	15	10	33	75	16	38.5%
11 Selenium	mg/kg (ppm)	0.31	0.67	0	0	0	0	0.0%
12.5 Phenols	mg/kg (ppm)			7	5.6	30	0.2	26.9%
16 Anthracene	mg/kg (ppm)			1	1	1	1	3.8%
18 Benz(a)anthracene (est)	mg/kg (ppm)			1	1	1	1	3.8%
20 Benzo(b)fluoranthene (est)	mg/kg (ppm)			2	1	1	1	7.7%
24 Butyl benzyl phthalate	mg/kg (ppm)			1	2	2	2	3.8%
28 Bis(2-ethylhexyl)phthalate	mg/kg (ppm)			14	91	520	1	53.8%
34 Chrysene (est)	mg/kg (ppm)			1	1	1	1	3.8%
42 Dimethylphthalate (est)	mg/kg (ppm)			1	1	1	1	3.8%
43 Di-n-butyl phthalate	mg/kg (ppm)			21	68	610	1	80.8%
47 Di-n-octylphthalate	mg/kg (ppm)			8	168	450	13	30.8%
49 Fluoranthene (est)	mg/kg (ppm)			5	2	6	1	19.2%
50 Fluorene (est)	mg/kg (ppm)			1	1	1	1	3.8%
56 Isophorone (est)	mg/kg (ppm)			3	3	6	1	11.5%
57 2-Methylnaphthalene (est)	mg/kg (ppm)			5	4	8	1	19.2%
58 Naphthalene	mg/kg (ppm)			6	10	51	1	23.1%
65 Phenanthrene (est)	mg/kg (ppm)			5	2	5	1	19.2%
67 Pyrene (est)	mg/kg (ppm)			4	1	1	1	15.4%
115 Benzene	mg/kg (ppm)			1	0.4	0.4	0.4	3.8%
119 Carbon disulfide	mg/kg (ppm)			1	16	16	16	3.8%
129 1,1-Dichloroethane	mg/kg (ppm)			2	1	1	0.4	7.7%
133 Ethylbenzene	mg/kg (ppm)			11	43	270	0	42.3%
134 Fluorotrichloromethane	mg/kg (ppm)			1	1	1	1	3.8%
136 Methylene chloride	mg/kg (ppm)			23	2	32	1	88.5%
138 Methyl ethyl ketone	mg/kg (ppm)			20	6	9	4	76.9%
140 Styrene	mg/kg (ppm)			1	1	1	1	3.8%
142 Tetrachloroethene	mg/kg (ppm)			1	1	1	1	3.8%
144 Toluene	mg/kg (ppm)			15	243	3,300	0	57.7%
149 Trichloroethene	mg/kg (ppm)			2	0	0	0	7.7%
152 m-xylene	mg/kg (ppm)			16	217	1,800	1	61.5%
153 o-xylene	mg/kg (ppm)			15	146	1,100	0	57.7%

areas of highest concentrations of total organics are in the very southern part of the site (6,481 ppm at SD1) and the east central part (6,366 ppm at SS11). Concentrations of total organics also exceed 1,000 ppm in the north central area (SS9 and SD3) (see Figure 4.2).

--In general, metals contamination decreases with depth, although there are a few locations where lead (SS4 and SS7) and cadmium (SS4) increased with depth (see Table 4.4). On the other hand, levels of total organics increased with depth at the same number of locations as they decreased with depth, indicating that migration of organics deeper into the soil profile is common (see Table 4.4). The average concentrations of organic constituents in samples from depressional areas are generally higher than for the same constituents in the grid samples, indicating that surface runoff has tended to concentrate organics in depressional areas. This does not appear to be a significant process for heavy metals.

--Levels of soil contamination can change greatly in relatively small distances. For example, SS9 contains the highest concentration of lead that was found on the site (38,000 ppm) and 1,334 ppm total organics. SD2, which is nearby, contained 380 ppm lead, and 117 ppm total organics (see Figure 4.2).

--Soil sample data from other sources (with the adjustment to the WAPORA data discussed above) are generally consistent with this study with respect to levels of inorganic contaminants (see Table 4.5). Data on organics from other sources are less extensive, but are also generally consistent with this study. A few organic contaminants have been identified in samples from other sources that were not found in this study. PCB's in concentrations ranging from 0.2 to 52 ppm were identified in five soil samples taken by the State of Illinois in 1980. The absence of PCB's

Table 4.4 Calumet Site, Changes in Selected Contaminants with Depth.

Concentrations	Increase w/depth	Decrease w/depth	Little Change
Grid samples (total organics)	SS4, SS6, SS7 SS8, SS11	SS1, SS2, SS3 SS5, SS9, SS10	SS12
Spot samples (total organics)	SD1, SD2	SD3	
Lead	SS4, SS7	SS1, SS2, SS3 SS5, SS6, SS8 SS9, SS10, SS11 SS12, SD2, SD3	SD1
Cadmium	SS4	SS2, SS3, SS5 SS6, SS7, SS8 SS9, SS10	SS11

SS = Grid (Systematic) Sample
SD = Spot (Depressional) Sample

Table 4.5. Comparison of Heavy Metal Concentrations in EMS Soil Samples With Other Soil Sampling Results.

	Element								
	Cn	As	Ba	Cd	Cr	Pb	Hg	Ni	Se
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
EMS (10/87)									
Grid (average)	13.8	34.9	724	7.6	236	2,470	2.1	33	0
Spot (average)	28.0	39.8	990	8.6	244	1,089	2.0	34	4.0
WAPORA (5/1/79) (entered as ppm rather than ppb)*									
2 Soil (15' west of pit)	4.1	7.5	77	2.9	365	2,500	0.002	17	4.7
3 Soil (30' S.E. of pit)	15.3	15.5	<5	84	2100	2,700	0.014	813	5.2
8B Soil (15' S.E. of pond)	0.25	11.6	56	<1.0	30	4,200	<.0002	25	<.1
Detection Limits (EMS Laboratory)	0.25	1.0	5.0	0.5	1.3	5.0	0.13	1.8	1.0
ISBH (5/22/79)*									
1 Soil N.W. of Bldg.	--	--	--	3.2	152	3.7	--	--	--
2 Soil/Sludge (conveyor end)	--	--	--	38.8	3,980	22,400	--	--	--
3 Soil/Sludge (conveyor end)	--	--	--	7.6	3,940	14,600	--	--	--
4 Soil/Sludge (conveyor end)	--	--	--	66.7	2,150	11,600	--	--	--
5A Soil (27' S. of trailer 3-10")	--	--	--	0.4	40	93	--	--	--
5A Soil (27' S. of trailer 10-14")	--	--	--	2	203	163	--	--	--
ISBH (9/5/79)*									
1 Sludge/soil 12' W. excav.	--	--	--	6.4	2,080	15,121	--	--	--
2 Sludge/soil W. edge excav.	--	--	--	25.9	2,916	19,896	--	--	--
4 Soil, N. of plant	--	--	--	32.0	5,638	4,864	--	--	--
5 Soil (6" off-site)	--	--	--	0.6	24.4	99	--	--	--
6 Soil (15" off-site)	--	--	--	ND	6.4	5.9	--	--	--
7 Soil from excavation	--	--	--	ND	6.3	4.4	--	--	--
EPA (6/14/83)									
8 NE of plant	ND	<0.5	424	32	917	7,570	1.1	195	<0.1
Northern Indiana Background	--	6.3	500	1	30	15	>1.5	15	0.67

* Adapted from Indiana Stream Pollution Control Board, Proposed Findings of Fact and Recommended Order (Cause No. B-659, 1980).

in any of Hydrosience's 38 soil samples indicates that PCB's, if still present on the site, are localized. EPA sample 10 (see Figure 4.1), taken in 1983, identified low concentrations of three organic contaminants that were not found in any of Hydrosience's soil samples: trans-1,3-dichloropropene (0.012 ppm) and 2-hexanone (0.121 ppm).

5.0 Analysis of Samples From Well Borings

During drilling of the three holes to bedrock (MW-1, MW-22, MW-23) samples were taken by the split-spoon technique, through the hollow-stem auger, at five-foot intervals. These samples were subsequently analyzed for moisture content, hydraulic conductivity, bulk density, particle size and cation-exchange capacity. In addition, samples from the clay aquitard were analyzed for Atterburg limits. Data from these analyses are summarized in Tables 5.1 to 5.6.

Examination of tabulated results shows that significant differences in certain properties occur between the surficial (Calumet) aquifer and the aquitard. For example, hydraulic conductivity is greatest in the upper five feet of the surficial aquifer and runs almost two orders of magnitude greater than that of the aquitard. It must be borne in mind that these values are determined from laboratory measurements and may differ from field measurements determined by pumping tests.

Bulk density of the sand in the surficial aquifer is approximately 20% greater than that of the clay aquitard. In general, the cation exchange capacity of the clay aquitard is two to four times that of the sandy surficial aquifer.

Table 5.1

Hydroscience Associates, Inc.
 Calumet Container project
 Page 1 of 9

Moisture Content (vol./vol.)

Depth	Hole Number		
	MW1	MW22	MW23
3.5 - 5	0.26	0.24	0.38
8.5 - 10	0.18	0.27	0.27
13.5 - 15	0.18	0.25	0.24
18.5 - 20	0.22	0.23	0.27 sand
23.5 - 25	0.18 sand	0.20 sand	0.24
28.5 - 30	0.19	0.21	0.24
33.5 - 35	0.19	0.72 clay	0.22
38.5 - 40	0.18	0.11	0.14 clay
43.5 - 45	0.2		
48.5 - 50	0.12		
53.5 - 55	0.11		
58.5 - 60	0.10 clay		
63.5 - 65	0.17		
75	0.11		
80	0.15		
Sand pack	0.02 bedrock		

Table 5.2

Hydroscience Associates, Inc.
 Calumet Container project
 Page 2 of 9

Hydraulic Conductivity (cm./hr.)

Depth	Hole Number		
	MW1	MW22	MW23
3.5 - 5	23.3	31.9	34.5
8.5 - 10	11.2	--	21.9
13.5 - 15	16.9	17.2	27.3
18.5 - 20	6.1	10.6	16.1 sand
23.5 - 25	0.33 sand	0.49 sand	0.43
28.5 - 30	0.49	0.46	0.36
33.5 - 35	0.24	56.0 clay	0.33
38.5 - 40	0.39	99.8	1.01 clay
43.5 - 45	0.55		
48.5 - 50	0.38		
53.5 - 55	0.31		
58.5 - 60	0.46 clay		
63.5 - 65	--		
75	--		
80	25.1		
Sand pack	98.2 bedrock		

Table 5.3

Hydroscience Associates, Inc.
 Calumet Container project
 Page 3 of 9

Bulk Density Packed (gm./cc.)

Depth	Hole Number		
	MW1	MW22	MW23
3.5 - 5	1.36	1.21	1.44
8.5 - 10	1.44	--	1.47
13.5 - 15	1.46	1.55	1.53
18.5 - 20	1.50	1.51	1.56
23.5 - 25	1.30 sand	1.21 sand	1.33 sand
28.5 - 30	1.29	1.17	1.13
33.5 - 35	1.26	-- clay	1.29 clay
38.5 - 40	1.27	--	1.40
43.5 - 45	1.52		
48.5 - 50	1.41		
53.5 - 55	1.41		
58.5 - 60	1.35 clay		
63.5 - 65	--		
75	--		
80	1.52		
Sand pack	1.56 bedrock		

Table 5.4

Hydroscience Associates, Inc.
 Calumet Container project
 Page 4 of 9

Atterburg Limits

Hole MW1

Depth	Liquid Limit	Plastic Limit	Plastic Index	Classification
3.5 - 5	--	--	NP	--
8.5 - 10	--	--	NP	--
13.5 - 15	--	--	NP	--
18.5 - 20	--	--	NP	--
<u>23.5 - 25 sand</u>	37.1	17.4	19.7	CL
28.5 - 30	37.0	16.8	20.2	CL
33.5 - 35	38.3	19.6	18.7	CL
38.5 - 40	36.9	17.6	19.3	CL
43.5 - 45	32.6	17.4	15.2	CL
48.5 - 50	26.5	15.0	11.5	CL
53.5 - 55	25.1	13.9	11.2	CL
<u>58.5 - 60 clay</u>	24.4	14.3	10.1	CL
63.5 - 65 bedrock	--	--	--	--

Table 5.4 (cont.)

Hydroscience Associates, Inc.
 Calumet Container project
 Page 5 of 9

Atterberg Limits

Hole MW22

Depth	Liquid Limit	Plastic Limit	Plastic Index	Classification
3.5 - 5	--	--	NP	--
8.5 - 10	--	--	NP	--
13.5 - 15	--	--	NP	--
18.5 - 20	--	--	NP	--
23.5 - 25 sand	32.9	18.9	14.0	CL
28.5 - 30	50.2	22.3	27.9	CH
33.5 - 35 clay	--	--	--	--

Hole MW23

Depth	Liquid Limit	Plastic Limit	Plastic Index	Classification
3.5 - 5	--	--	NP	--
8.5 - 10	--	--	NP	--
13.5 - 15	--	--	NP	--
18.5 - 20 sand	--	--	NP	--
23.5 - 25	34.7	17.4	17.3	CL
28.5 - 30	47.7	21.9	25.8	CL
33.5 - 35 clay	35.6	19.4	16.2	CL
35.0 - 40	25.0	16.3	8.7	CL

Table 5.5

Hydroscience Associates, Inc.
Calumet Container project
Page 6 of 9

Particle Size Analysis

Hole MW1

Depth	Very Coarse Sand %	Coarse Sand %	Medium Sand %	Fine Sand %	Very Fine Sand %	Total Sand %	Silt %	Fine Silt %	Clay %	Text Class
3.5 - 5	0.1	0.2	1.2	81.0	8.6	91.1	8.0	3.3	0.9	S
8.5 - 10	2.5	3.1	3.6	63.5	12.0	84.7	13.1	6.7	2.2	S
13.5 - 15	0.0	0.1	0.1	61.0	28.1	89.3	9.1	4.2	1.6	S
18.5 - 20	0.0	0.2	0.2	5.9	77.9	84.2	14.0	6.4	1.8	S
23.5 - 25 sand	0.5	0.3	0.5	1.0	0.8	3.1	51.7	42.0	45.2	SiC
28.5 - 30	0.3	0.4	0.6	2.3	1.4	5.0	51.9	50.9	43.1	SiC
33.5 - 35	0.8	1.1	1.4	2.2	1.6	7.1	47.7	43.4	45.2	SiC
38.5 - 40	0.8	1.7	1.8	1.7	1.9	7.9	47.0	41.0	45.1	SiC
43.5 - 45	1.5	2.5	2.7	4.2	2.8	13.7	48.4	37.2	37.9	SiCL
48.5 - 50	2.5	4.6	4.8	6.7	4.5	23.1	50.8	32.7	26.1	SiC
53.5 - 55	3.4	4.5	4.6	5.8	4.4	22.7	52.5	43.2	24.8	SiL
58.5 - 60 clay	3.3	5.2	4.2	5.6	5.3	23.6	52.3	37.4	24.1	SiL
63.5 - 65 B.Rk	31.0	23.6	6.8	5.3	3.1	69.8	20.2	11.1	10.0	SL

Table 5.5 (cont.)
Particle Size Analysis

Hole MW22

Depth	Very Coarse Sand %	Coarse Sand %	Medium Sand %	Fine Sand %	Very Fine Sand %	Total Sand %	Silt %	Fine Silt %	Clay %	Text Class
3.5 - 5	6.8	9.6	35.9	38.4	2.5	93.2	2.9	5.1	1.7	S
8.5 - 10	0.4	0.4	6.9	85.9	3.5	97.1	0.6	2.0	0.9	S
13.5 - 15	0.0	0.1	1.3	87.4	6.7	95.6	2.2	3.4	1.1	S
18.5 - 20	0.0	0.0	0.4	52.3	34.7	87.4	2.7	11.3	1.3	S
23.5 - 25 sand	0.0	0.1	0.9	2.7	1.7	5.4	49.4	57.8	36.8	SiCL
28.5 - 30	--	--	--	--	--	--	--	--	--	--
33.5 - 35 clay	0.2	0.9	5.1	6.8	3.3	96.1	1.8	2.8	1.0	S

Hole MW23

Depth	Very Coarse Sand %	Coarse Sand %	Medium Sand %	Fine Sand %	Very Fine Sand %	Total Sand %	Silt %	Fine Silt %	Clay %	Text Class
3.5 - 5	0.0	0.1	1.0	84.2	8.4	93.7	2.4	2.8	3.4	S
8.5 - 10	0.0	0.0	0.8	82.1	14.1	97.1	1.0	2.0	0.9	S
13.5 - 15	0.0	0.0	0.3	23.9	54.1	78.3	4.4	19.5	2.1	LS
18.5 - 20 sand	0.1	0.0	0.4	3.5	2.1	6.1	47.1	54.0	39.8	SiCL
23.5 - 25	0.1	0.1	0.6	3.8	2.6	7.2	27.3	33.3	59.5	C
28.5 - 30	0.5	0.5	1.7	3.2	2.4	8.4	40.1	48.0	43.5	SiC
33.5 - 35 clay	3.6	6.5	5.6	8.2	4.0	28.0	37.5	50.1	21.8	Sil

Table 5.6

Hydroscience Associates, Inc.
 Calumet Container project
 Page 8 of 9

Cation Exchange Capacity (meq./100 g)

Hole MW1

Depth	Ca	Mg	K	Na	Acid	CEC Total	Sat. %
3.5 - 5	6.02	0.58	0.01	0.515	0.00	7.12	100.00
8.5 - 10	10.03	1.24	0.03	0.318	0.00	11.61	100.00
13.5 - 15	6.51	0.66	0.03	0.261	0.00	7.46	100.00
18.5 - 20	8.02	0.74	0.01	0.092	0.00	8.87	100.00
<u>23.5 - 25 sand</u>	16.65	3.07	0.40	0.154	1.19	21.46	94.46
28.5 - 30	17.17	3.08	0.41	0.242	0.59	21.50	97.23
33.5 - 35	17.15	2.91	0.41	0.285	0.40	21.16	98.13
38.5 - 40	17.15	2.66	0.44	0.342	0.59	21.19	97.20
43.5 - 45	18.13	2.57	0.44	0.315	0.59	22.04	97.31
48.5 - 50	18.18	2.41	0.41	0.237	0.40	21.64	98.17
53.5 - 55	15.58	2.23	0.41	0.253	0.59	19.07	96.90
<u>58.5 - 60 clay</u>	17.09	2.15	0.41	0.197	0.39	20.24	98.05
63.5 - 65 bedrock	9.54	2.15	0.27	0.131	0.00	12.09	100.00

Table 5.6 (cont.)

Cation Exchange Capacity (meq./100 g)

Hole MW22

Depth	Ca	Mg	K	Na	Acid	CEC Total	Sat. %
3.5 - 5	4.01	0.99	0.12	0.087	0.00	5.20	100.00
8.5 - 10	4.00	0.16	0.03	0.017	0.00	4.21	100.00
13.5 - 15	5.00	0.41	0.06	0.043	0.00	5.52	100.00
18.5 - 20	6.00	0.58	0.06	0.087	0.00	6.73	100.00
23.5 - 25 sand	17.50	2.80	0.40	0.096	0.00	20.79	100.00
28.5 - 30	32.00	4.94	0.69	0.165	0.00	37.79	100.00
33.5 - 35 clay	2.00	0.41	0.04	0.078	0.00	2.53	100.00

Cation Exchange Capacity (meq./100 g)

Hole MW 23

Depth	Ca	Mg	K	Na	Acid	CEC Total	Sat. %
3.5 - 5	6.50	0.49	0.03	0.143	0.00	7.16	100.00
8.5 - 10	4.50	0.33	0.01	0.057	0.00	4.90	100.00
13.5 - 15	8.00	0.74	0.04	0.026	0.00	8.81	100.00
18.5 - 20 sand	17.59	3.39	0.45	0.131	0.00	21.56	100.00
23.5 - 25	18.63	4.31	0.63	0.250	0.00	23.82	100.00
28.5 - 30	18.11	3.06	0.51	0.192	0.00	21.88	100.00
33.5 - 35 clay	16.05	2.64	0.42	0.131	0.00	19.24	100.00

List of References

Lohman, S.W., 1972, Ground water hydraulics: USGS Professional Paper 708,
p. 34-40.

Rosenshein, J.S., 1961, Ground water resources of Northwestern Indiana,
Preliminary Report: Lake County: Indiana Dept. Conserv. Bullet. No.
10, 229 p.

Shedlock, R. and L. Watson, 1986, United States Geological Survey Staff:
personal communication.

U.S. Soil Conservation Service. 1972, Soil Survey of Lake County.

APPENDIX A

Well Logs

Modifications to Original Drilling and
Health and Safety Specifications
Calumet Container Site, Hammond, Indiana

1. The last well to be drilled, MW-23, a bedrock monitoring well, had originally been intended for the cluster containing Wells MW-20 and MW-21 on the east side of the pond (see attached figure). The latter two wells were drilled in early November while the site was still fairly dry and drilling equipment could be moved to the site. To get to this site, one has to drive across a low area which became covered with water after MW-20 and MW-21 were drilled, making it impossible to drive a rig into the area to drill MW-23.

Hydroscience Associates, Inc. approached IDEM with a request to change the location of MW-23 to a point just west of the pond near the gate to the site. IDEM granted permission and MW-23 was completed at the new site (see Figure A-1) on December 23, 1987. During the entire course of drilling of this hole, the HNu meter did not register.

2. A change in drilling methods was also necessary for bedrock holes MW-22 and MW-23. Because the rock was so hard (siliceous dolomite), D. I. Leap approached Mr. Dan Stropes of IDEM with a request to drill through the bedrock with a diamond core barrel to make a hole for the 2 inch screen. Permission was granted and drilling time was reduced to 0.10 that required for rotary-bit drilling. In addition, a cored section of the bedrock was retrieved from each site.

In the drilling of MW-23, the bedrock appeared even harder than at MW-22. D. I. Leap asked IDEM on December 23, 1987 for permission to drill only 2-1/2 feet into the bedrock instead of the specified 5 feet with a 5-7/8 inch bit to set the 4 inch casing. Permission was granted and about five hours of extra drilling was saved. The bedrock was then cored as in the case of MW-22 for the 2 inch screen.

3. During the week of December 20, 1987, scheduling of health and safety personnel was very difficult due to the approaching holidays. Mr. Richard Land of HSE in Columbus, Indiana agreed to bring the health and safety van and work for two days, December 21 and 22. The IDEM agreed to keeping health and safety personnel at the site while drilling only through the unconsolidated, potentially contaminated material. After this material was penetrated and sealed off, formal health and safety personnel could be released as long as there was a person from IDEM to monitor the site and an extra person from Hydroscience to help with decontamination.

After penetrating the unconsolidated material in MW-23, Mr. Land left the site in the afternoon of December 22, 1987. The next day, Dr. John Cushman of Hydroscience arrived. Mr. Arthur Carter worked from December 21 to the afternoon of December 22. Dr. Swapan Ghosh worked until the hole was finished on December 23, and everyone left the site after decontamination.

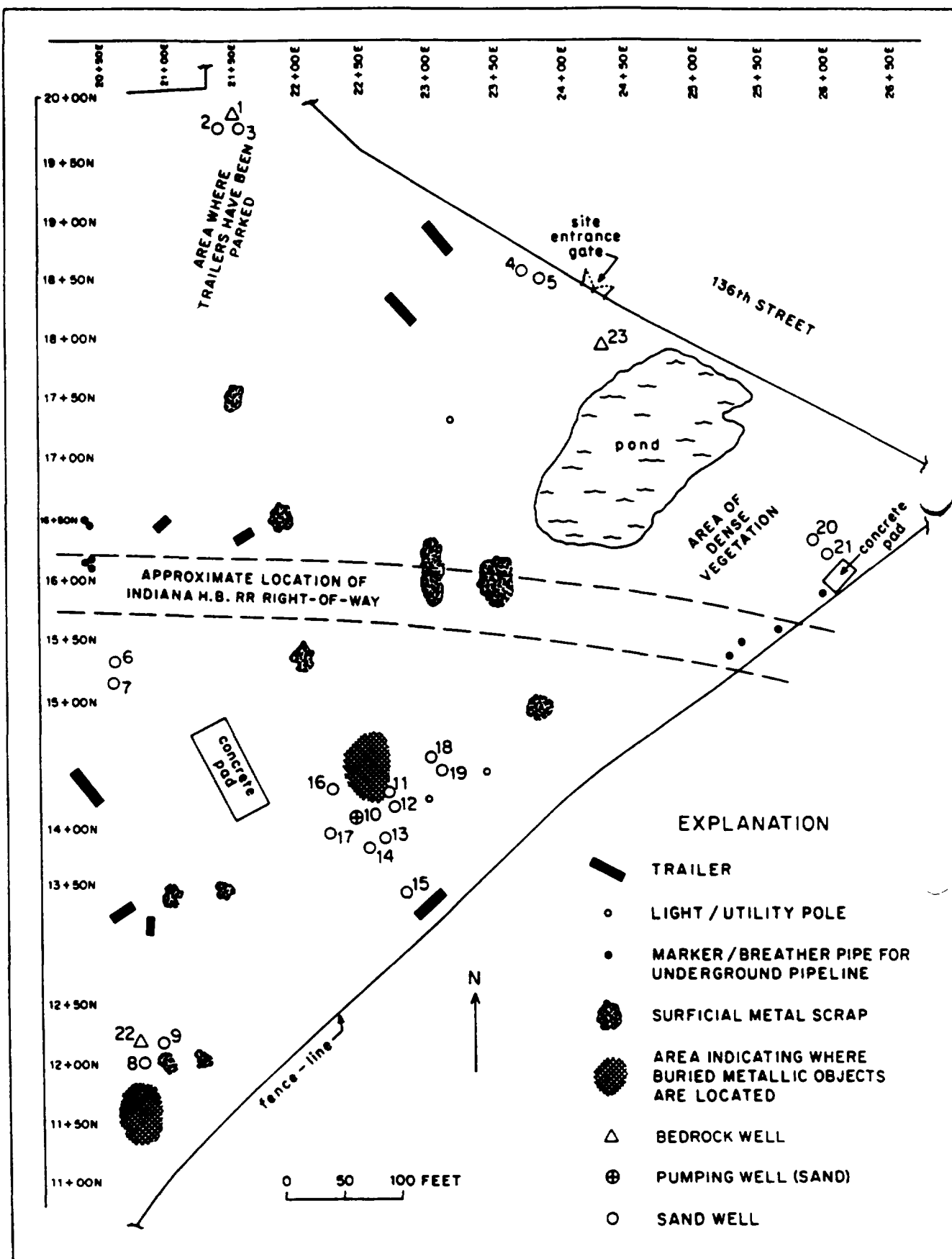


Figure A.1 Map showing location of wells on the Calumet Container Site.

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 1 of 4

Well Number MW-1 Ground Elevation 585.0

Project Calumer Containers - IDEM Date 7-8-87

Driller A. Belasco Geologists D. Leap, N. Krothe,
R. Funkhouser

Location 19+80N, 21+50E
NW portion of the site
T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger and Rotary Wash

Casing type/length: PVC / 69 ft Diameter 2 inch

Screen type/length: Stainless Steel / 11 ft Diameter 2 inch

Screen slot size: .010" Screen depth 69' to 80'

Gravel pack: Coarse sand to 1' above the screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Brownish-black sandy silt. Small roots and other organic matter noted.	0	3.5'		
Brownish-gray, fine silty sand. Saturated @ 3.5'	3.5'	5.0'	3.5' - 5.0'	8-5-3
Brownish-gray, fine sand.	5.0'	10.0'	8.5' - 10'	11-15-14
20" of heaving sand in the drill rod. Pulled augers to place basket in the lead auger.	10'	13'		
Brownish-gray, fine sand. Still getting about 20" of heave @ 18.5' - 20'	13.5'	24.5'	13.5' - 15' 18.5' - 20'	5-12-16 9-8-12-10 (first two numbers are speculative due to heav ing sand.)
HNu Readings: Background				

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 2 of 4

Well Number MW-1 (cont'd.) Ground Elevation _____

Project _____ Date _____

Driller _____ Geologist _____

Location _____

Construction Details

Method of drilling:

Casing type/length: _____ ft Diameter _____ inch

Screen type/length: _____ ft Diameter _____ inch

Screen slot size: _____ Screen depth _____ to _____

Gravel pack: _____

Well Log

Well Log				
Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Gray clay (appears to be lacustrine).	24.5'	35'	23.5' - 25'	8-4-7
			28.5' - 30'	4-5-9
			33.5' - 35'	7-7-9
Gray clay till. Small shale chips noted in clay. Very tight.	35'	45'	38.5' - 40'	8-9-12
			43.5' - 45'	12-13-20
<u>July 9, 1987</u>				
Gray clay till. Very tight, brittle, very little water content. Possible fractures-- may be stress release fractures. Harder drilling @ 45'. Changed to rotary wash method of drilling at 50'.	45'	61'	48.5' - 50'	13-24-33
			53.5' - 55'	17-33-50-5
			58.5' - 60'	33-44-50-5
Gray dolomite/limestone mixed with black shale.	61'	80'		

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 3 of 4

Well Number MW-1 (cont'd.) Ground Elevation

Project Date

Driller Geologist

Location

Construction Details

Method of drilling:

Casing type/length: ft Diameter inch

Screen type/length: ft Diameter inch

Screen slot size: Screen depth to

Gravel pack:

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Total well depth 80'				
Comments: Bentonite added from 68' to 67'. Grouted to surface with bentonitic cement. HNu readings did not exceed background.				
Specific drilling and construction details have been included on the following page.				

HYDROSCIENCE ASSOCIATES, INC.

Test Well Record

Page 4 of 4

Drilling and Construction Details - MW1

1. The hole was drilled by the hollow stem auger method from 0-50 ft. (4-1/4 in. ID, 7-1/2 in. OD)
2. At 50 ft., changed to rotary wash method of drilling using 3-3/8 in. drag bit.
3. Encountered bedrock at 61 ft. Augers were pulled out. Six (6) in. PVC casing was set to a depth of 50 ft. by washing it down.
4. A roller bit was used to ream to a diameter of 5-3/4 in. from 50 ft. to 61 ft. The bit was advanced 5 ft. into bedrock.
5. All drill tools were pulled out of the hole.
6. Four (4) in. PVC casing was installed to a depth of 66 ft. and pressure grouted with bentonitic cement to the surface. This procedure completely filled the annulus between the 4 in. casing and the hole sidewalls with grout in the section from 50-66 ft. Above 50 ft., the cement filled the annulus between the 4 in. and 6 in. casing. The 6 in. casing was pulled while the grout was still wet; consequently, the grout filled the annulus between the hole sidewalls and the 4 in. casing.
7. A 3-7/8 in. bit was used to drill through the 4 in. casing and advance the hole to a depth of 80 ft.
8. Two (2) in. diameter screen and riser pipe was installed. Sand pack, bentonite and grout was added. The grout filled the annulus between the riser and the 4 in. casing.

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 1

Well Number MW-2 Ground Elevation 585.07

Project Calumet Containers - IDEM Date 7-16-87

Driller A. Belasco Geologists D. Leap, N. Krothe

Location 19+75N, 21+40E
NW portion of the site
T. 37N., R. 10W., Sec. 24, NW 1/4

Construction Details

Method of drilling: Hollow Stem Auger

Casing type/length: PVC / 4.0 ft Diameter 2 inch

Screen type/length: Stainless Steel / 1ft Diameter 2 inch

Screen slot size: .010" Screen depth 4' to 15'

Gravel pack: Coarse sand to 3' above the screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Brownish-gray, fine sand	0	16'	None	None
Total well depth 15'				
Comments: Grouted with bentonitic cement to surface. Installed steel protective cover.				
HNu Readings: Background				

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 1

Well Number MW-3 Ground Elevation 585.07

Project Calumet Containers - IDEM Date 7-17-87

Driller A. Belasco Geologists D. Leap, N. Krothe

Location 19+75N, 21+60E
NW portion of the site
T.37N.. R.10W.. Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger

Casing type/length: PVC / 13.0 ft Diameter 2 inch

Screen type/length: Stainless Steel/ 11 ft Diameter 2 inch

Screen slot size: .010" Screen depth 13.5' to 24.5'

Gravel pack: Coarse sand to 1.5' above the screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Brownish-gray, fine sand	0	23	None	None
Gray clay	23'	25'	None	None
Total well depth 24.5'				
Comments: 1.5' bentonite plug installed above sand pack. Grouted with bentonitic cement to surface.				
HNu Readings: Background				

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 1

Well Number NW-4 Ground Elevation 585.0
 Project Calumet Containers - IDEM Date 7-20-87
 Driller A. Belasco Geologist D. Leap
 Location 18+70N, 23+60E
 Near site entrance gate, west side
 T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger
 Casing type/length: PVC / 4.5 ft Diameter 2 inch
 Screen type/length: Stainless Steel/ 11 ft Diameter 2 inch
 Screen slot size: .010" Screen depth 4.5' to 15.5'
 Gravel pack: Coarse sand to 1.5' above the screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Dark gray, silt. (Fill material)	0	2.5'	None	None
Brown fine sand.	2.5'	4.0'	None	None
Black sand. Saturated.	4.0'	10.0'	None	None
Brownish-gray, fine sand.	10.0'	15.0'	None	None
Total well depth 15.5'				
Comments: Water table @ 4'. Bentonite pellets from 3.5' to 2.5'; grouted with bentonitic cement to surface.				
HNu Readings: Background				

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 1

Well Number MW-5 Ground Elevation 585.0

Project Calumet Container - IDEM Date 7-20-87

Driller A. Belasco Geologist D. Leap

Location 18+70N, 23+70E
Near site entrance gate, west side
T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger

Casing type/length: PVC / 14 ft Diameter 2 inch

Screen type/length: Stainless Steel/ 11 ft Diameter 2 inch

Screen slot size: .010" Screen depth 14' to 25'

Gravel pack: Coarse sand to 1' above the screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Dark gray silt (fill material).	0	2.5'	None	None
Brown fine sand.	2.5'	4.0'	None	None
Black sand. Saturated.	4.0'	10.0'	None	None
Brownish-gray, fine sand.	10.0'	25.0'	None	None
Gray clay.	25.0'			
Total well depth 25'				
Comments: Bentonite slurry 11.5-13'. Grouted to surface with bentonitic cement.				
HNU Readings: Background				

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 1 of 1

Well Number MW-6 Ground Elevation 587.0

Project Calumet Containers - IDEM Date 7-21-87

Driller A. Belasco Geologist D. Leap

Location 15+40N, 20+75E
Midway along western border of site
T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger

Casing type/length: PVC / 4 ft Diameter 2 inch

Screen type/length: Stainless Steel/ 11 ft Diameter 2 inch

Screen slot size: .010" Screen depth 4' to 15'

Gravel pack: Pea gravel to 1' above the screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Brown, sandy silt fill material with gravel and small chunks of concrete.	0	2'	None	None
Brownish-gray fine sand.	2'	15'	None	None
Total well depth 15'				
Comments: Bentonite pellets added from 3' to 2'. Grouted to surface with bentonitic cement.				
HNu readings (inside auger): 2 ppm @ 2' 5 ppm @ 10' 12 ppm @ 15'				

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 1

Well Number MW-7 Ground Elevation 587.0
 Project Calumet Containers - IDEM Date 7-21-87
 Driller A. Belasco Geologists D. Leap, R. Funkhouser
 Location 15+30N, 20+75E
Midway along western border of site
T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger
 Casing type/length: PVC / 14.0 ft Diameter 2 inch
 Screen type/length: Stainless Steel / 11 ft Diameter 2 inch
 Screen slot size: .010" Screen depth 14' to 25'
 Gravel pack: Pea gravel to 1' above the screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Brown, sandy silt fill material with gravel and small chunks of concrete.	0	2'	None	None
Brownish-gray fine sand.	2'	25'	None	None
Gray clay.	25'			
Total well depth 25'				
Comments: Bentonite pellets added from 13' to 12'. Grouted to surface with bentonitic cement. Brown, oily staining noted on augers.				
INu readings (inside auger): 10 ppm @ 5' 15 ppm @ 15' 5 ppm @ 25'				

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 1 of 1

Well Number MW-8 Ground Elevation 587.0

Project Calumet Containers - IDEM Date 7-22-87

Driller A. Belasco Geologist R. Funkhouser

Location 12+10N, 21+00E
Near southernmost tip of site
T.37N., R.10W., Sec. 24, NW1/4

Construction Details

Method of drilling: Hollow Stem Auger

Casing type/length: PVC / 4.0 ft Diameter 2 inch

Screen type/length: Stainless Steel / 11ft Diameter 2 inch

Screen slot size: .010" Screen depth 4' to 15'

Gravel pack: Pea gravel to 1' above the screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Brown, sandy silt fill material with gravel and small chunks of concrete.	0	1.5'	None	None
Black, tarry, sludge-like material.	1.5'	7.0'	None	None
Black fine sand. Saturated.	7.0'	15.0'	None	None
Total well depth 15'				
Comments: Bentonite pellets added from 3' to 2'. Grouted to surface with bentonitic cement. Oily sheen noted on augers as they were pulled out.				
HNu readings (inside auger): 60-70 ppm @ 1.5' - 15'				

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 1

Well Number MW-9 Ground Elevation 587.0

Project Calumet Containers - IDEM Date 11-4-87

Driller A. Belasco Geologist R. Funkhouser

Location 12+20N, 21+10E
Near southernmost tip of site
T.37N., R.10W., Sec. 24, NW1/4

Construction Details

Method of drilling: Hollow Stem Auger

Casing type/length: PVC / 13.5 ft Diameter 2 inch

Screen type/length: Stainless Steel / 11ft Diameter 2 inch

Screen slot size: .010" Screen depth 14.75' to 25.75'

Gravel pack: Pea gravel to 2' above the screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Black, bituminous silty sand.	0	3.5'	None	
Black silty sand. Much cleaner type material than at Well 8. Augers were not stained by sludge as they were at Well 8.	3.5'	5.0'		
Dark, brownish-gray fine sand. Saturated @ 5'. Slight oily sheen at 12'.	5.0'	25.5'		
Gray clay.	25.5'	26.0'		
Total well depth 25.75'				
Comments: Bentonite slurry added from 11.75' to 12.75'. Grouted to surface with bentonitic cement.				
HNu Readings (inside auger):				
0-20 ppm @ 3.5'				
Background @ 10'				
4 ppm @ 15'				
Background @ 15'-26'				

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 1

Well Number PW-10 Ground Elevation 586.0

Project Calumet Containers - IDEM Date 11-4-87

Driller A. Belasco Geologist R. Funkhouser

Location 14+10N, 22+50E
T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger

Casing type/length: PVC / 2.0 ft Diameter 4 inch

Screen type/length: PVC / 20.0 ft Diameter 4 inch

Screen slot size: .010" Screen depth 2' to 22'

Gravel pack: Pea gravel to top of screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Slag material. Concrete chunks.	0	1.8'	None	
Black bituminous silty sand. Saturated @ 4.5'.	1.8'	5.0'		
Dark, brownish-gray fine sand.	5.0'	22.5'		
Gray clay.	22.5'			
Total well depth 22'				
Comments: Bentonite pellets added from 1.5' to 2'. Grouted to surface with bentonitic cement.				
HNu Readings: Background				

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 1

Well Number OW-11 Ground Elevation 586.0
 Project Calumet Containers - IDEM Date 11-5-87
 Driller A. Belasco Geologist R. Funkhouser
 Location 14+20N, 22+60E
18.83 feet NE of pumping well (PW-10)
T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger
 Casing type/length: PVC / 8.0 ft Diameter 2 inch
 Screen type/length: PVC / 2.0 ft Diameter 2 inch
 Screen slot size: .010" Screen depth 8' to 10'
 Gravel pack: Pea gravel to 2.5' above screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Fill material. Gravel, small concrete chunks.	0	0.5'	None	
Brown sandy silt with some natural organic matter (roots).	0.5'	1.5'		
Dark gray to black sandy silt.	1.5'	3.5'		
Dark brownish-gray fine sand.	5.0'	10.0'		
Total well depth 10'				
Comments: Bentonite slurry added from 6.5' to 5'. Grouted to surface with bentonitic cement.				
HNu Readings: Background				

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 1 of 1

Well Number OW-12 Ground Elevation 586.0
 Project Calumet Containers - IDEM Date 11-5-87
 Driller A. Belasco Geologist R. Funkhouser
 Location 14+25N, 22+65E
15.95' NE of PW-10
T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger
 Casing type/length: PVC / 5.1 ft Diameter 2 inch
 Screen type/length: PVC / 2.0 ft Diameter 2 inch
 Screen slot size: .010" Screen depth 5.1' to 7.1'
 Gravel pack: Pea gravel to 1.8' above screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Fill material (gravel, small concrete chunks mixed with brown sandy silt).	0	0.5'	None	
Black sandy silt.	0.5'	3.5'		
Dark brownish-gray fine sand. Saturated @ 4'.	3.5'	7.1'		
Total well depth 7.1'				
Comments: Bentonite slurry added from 3.3' to 2.3'. Grouted to surface with bentonitic cement.				
HNu Readings (inside auger): 6 ppm @ 5'				
Background @ 7'				

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 1 of 1

Well Number OW-13 Ground Elevation 585.7

Project Calumet Conatiners - IDEM Date 11-5-87

Driller A. Belasco Geologist R. Funkhouser

Location 13+90E, 22+70E
17.9' SE of PW-10
T.37N.. R.10W.. Sec. 24. NW1/4

Construction Details

Method of drilling: Hollow Stem Auger

Casing type/length: PVC / 8.0 ft Diameter 2 inch

Screen type/length: PVC / 2.0 ft Diameter 2 inch

Screen slot size: .010" Screen depth 8.0' to 10.0'

Gravel pack: Pea gravel to 1.5' above screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Fill material (gravel, small concrete chunks mixed with brown sandy silt).	0	0.5'	None	
Black sandy silt.	0.5'	3.5'		
Dark brownish-gray fine sand. Saturated @ 4'.	3.5'	10.0'		
Total well depth 10'				
Comments: Bentonite slurry 5.0-6.5'. Grouted to surface with bentonitic cement.				
HNu Readings: Background				

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 1 of 1

Well Number OW-14 Ground Elevation 585.7
 Project Calumet Containers - IDEM Date 11-6-87
 Driller A. Belasco Geologist R. Funkhouser
 Location 13+80N, 22+60E
17.7' SE of PW-10
T.37N., R.10W., Sec. 24, NW¼

Construction Details

Method of drilling: Hollow Stem Auger
 Casing type/length: PVC / 5.0 ft Diameter 2 inch
 Screen type/length: PVC / 2.0 ft Diameter 2 inch
 Screen slot size: .010" Screen depth 5.0' to 7.0'
 Gravel pack: Pea gravel to 1.5' above screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Fill material (gravel, small concrete chunks mixed with brown sandy silt).	0	0.5'	None	
Black sandy silt.	0.5'	3.5'		
Dark brownish-gray fine sand. Saturated @4'.	3.5'	8.0'		
Total well depth 7.0'				
Comments: Bentonite slurry 2.4-3.5'. Grouted to surface with bentonitic cement.				
HNu Readings: Background				

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 1

Well Number OW-15 Ground Elevation 585.5

Project Calumet Containers - IDEM Date 11-6-87

Driller A. Belasco Geologist R. Funkhouser

Location 13+50N, 21+00E
74.5' SE of PW-10
R.37N.. R.10W.. Sec. 24. NW1/4

Construction Details

Method of drilling: Hollow Stem Auger

Casing type/length: PVC / 5.0 ft Diameter 2 inch

Screen type/length: PVC / 2.0 ft Diameter 2 inch

Screen slot size: .010" Screen depth 5.0' to 7.0'

Gravel pack: Pea gravel to 1.5' above screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Fill material (small concrete chunks with brown sandy silt).	0	1.0'	None	
Black sandy silt.	1.0'	3.5'		
Dark brownish-gray fine sand.	3.5'	7.0'		
Total well depth 7.0'				
Comments: Bentonite pellets 2.5-3.5'. Grouted to surface with bentonitic cement.				
HNu Readings (inside auger): 8-15 ppm @ 3.5' Background @ 7.0'				

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 1 of 1

Well Number OW-16 Ground Elevation 586.0

Project Calumet Containers - IDEM Date 11-6-87

Driller A. Belasco Geologist R. Funkhouser

Location 14+90N, 22+30E
19.8' NW of PW-10
T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger

Casing type/length: PVC / 19.9 ft Diameter 2 inch

Screen type/length: PVC / 2.0 ft Diameter 2 inch

Screen slot size: .010" Screen depth 19.9' to 21.9'

Gravel pack: Pea gravel to 1.5' above screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Fill material (gravel, small concrete chunks mixed with brown sandy silt).	0	2.0'	None	
Black sandy silt.	2.0'	3.5'		
Dark brownish-gray fine sand. Saturated @ 3.5'	3.5'	22.0'		
Gray clay.	22.0'			
Total well depth 21.9'				
Comments: Bentonite slurry 17.4-18.4'. Grouted to surface with bentonitic cement.				
HNu Readings: Background				

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 1 of 1

Well Number OW-17 Ground Elevation 586.0

Project Calumet Containers - IDEM Date 11-9-87

Driller A. Belasco Geologist R. Funkhouser

Location 14+00N, 22+30E
19.25' SW of PW-10
T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger

Casing type/length: PVC / 20 ft Diameter 2 inch

Screen type/length: PVC / 2 ft Diameter 2 inch

Screen slot size: .010" Screen depth 20' to 22'

Gravel pack: Pea gravel to 1.3' above screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Fill material (gravel, concrete chunks mixed with brown sandy silt).	0	2'	None	
Black organic-rich sandy silt. Saturated @ 3.5'	2.0'	3.5'		
Dark brownish-gray fine sand.	3.5'	22.5'		
Gray clay.	22.5'			
Total well depth 22'				
Comments: Bentonite slurry 17.7-18.7'. Grouted to surface with bentonitic cement.				
HNu Readings (inside auger): 6 ppm @ 5'				
Background @ 5-22.5'				

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 2

Well Number MW-18 Ground Elevation 585.8
 Project Calumet Containers - IDEM Date 11-9-87
 Driller A. Belasco Geologist R. Funkhouser
 Location 14+60N, 23+00N
75.0' NE of PW-10
T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger
 Casing type/length: PVC / 2.7 ft Diameter 2 inch
 Screen type/length: Stainless Steel/ 11 ft Diameter 2 inch
 Screen slot size: .010" Screen depth 2.7' to 13.7'
 Gravel pack: Pea gravel to 0.7' above screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Fill material (gravel mixed with brown sandy silt and black sludge. Flecks of green and yellow in the sludge).	0	1.5'	None	
Black bituminous sludge.	1.5'	3.5'		
Dark brownish-gray fine sand. Saturated @ 3.5'	3.5'	14.0'		
Total well depth 13.7'				
Comments: Bentonite pellets 2.0-1.3'. Grouted to surface with bentonitic cement. Washed out sand plug in bottom of auger with clean water. This water became green in color when it contacted the greenish material in the sludge at the surface. (cont'd.)				

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 2 of 2

Well Number MW-18 (cont'd.) Ground Elevation _____

Project _____ Date _____

Driller _____ Geologist _____

Location _____

Construction Details

Method of drilling:

Casing type/length: _____ ft Diameter _____ inch

Screen type/length: _____ ft Diameter _____ inch

Screen slot size: _____ Screen depth _____ to _____

Gravel pack: _____

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
------------------------	------	----	--------------	----------

One wheel of the rig sank approximately 1' in soft sludgy material before being stabilized.				
---	--	--	--	--

HNu Readings (inside auger):

16 ppm @ 1.0'

10 ppm @ 3.0' (outside auger)

3 ppm @ 3.0' (inside auger)

1 ppm @ 5.0'

1 ppm @ 10.0'

6 ppm @ 14.0'

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 1 of 1

Well Number MW-19 Ground Elevation 585.8
 Project Calumet Containers - IDEM Date 11-9-87
 Driller A. Belasco Geologist R. Funkhouser
 Location 14+50N, 23+10E
 76.0' NE of PW-10
 T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger
 Casing type/length: PVC / 12 ft Diameter 2 inch
 Screen type/length: Stainless Steel/ 11 ft Diameter 2 inch
 Screen slot size: .010" Screen depth 12' to 23'
 Gravel pack: Pea gravel to 2' above screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Fill material. Brownish-black sandy silt with small gravel. Slight bituminous tint. Not as much sludge as encountered during drilling of Well 18.	0	2'	None	
Black sandy silt. May be natural.	2'	3.5'		
Dark brownish-gray fine sand. Saturated @ 3.5'	3.5'	22.5'		
Gray clay.	22.5'	23.0'		
Total well depth 23'				
Comments: Bentonite slurry 9-10'. Grouted to surface with bentonitic cement.				
HNu Readings: Battery was weak. Could not take readings.				

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 2

Well Number MW-20 Ground Elevation 585.0
 Project Calumet Containers - IDEM Date 11-10-87
 Driller A. Belasco Geologist R. Funkhouser
 Location 16+40N, 25+90E
T37N., R.10W., Sec. 24, NW $\frac{1}{4}$

Construction Details

Method of drilling: Hollow Stem Auger
 Casing type/length: PVC / 19.5 ft Diameter 2 inch
 Screen type/length: Stainless Steel/ 11 ft Diameter 2 inch
 Screen slot size: .010" Screen depth 19.5' to 30.5'
 Gravel pack: Pea gravel to 1' above screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Fill. Black, sandy silt with rootlets.	0	1.0'	None	
Fill. Brown coarse sand.	1.0'	2.5'		
Black, sandy silt (appears to be natural).	2.5'	3.5'		
Dark brownish-gray fine sand. Saturated @ 4'.	3.5'	30.0'		
Dark brown coarse sand.	30.0'	30.5'		
Gray clay.	30.5'			
Total well depth 30.5'				
(cont'd.)				

HYDROSCIENCE ASSOCIATES, INC.

TEST WELL RECORD

Page 2 of 2

Well Number	MW-20 (cont'd.)	Ground Elevation
1	10.0	10.0
2	10.0	10.0
3	10.0	10.0
4	10.0	10.0
5	10.0	10.0
6	10.0	10.0
7	10.0	10.0
8	10.0	10.0
9	10.0	10.0
10	10.0	10.0
11	10.0	10.0
12	10.0	10.0
13	10.0	10.0
14	10.0	10.0
15	10.0	10.0
16	10.0	10.0
17	10.0	10.0
18	10.0	10.0
19	10.0	10.0
20	10.0	10.0
21	10.0	10.0
22	10.0	10.0
23	10.0	10.0
24	10.0	10.0
25	10.0	10.0
26	10.0	10.0
27	10.0	10.0
28	10.0	10.0
29	10.0	10.0
30	10.0	10.0
31	10.0	10.0
32	10.0	10.0
33	10.0	10.0
34	10.0	10.0
35	10.0	10.0
36	10.0	10.0
37	10.0	10.0
38	10.0	10.0
39	10.0	10.0
40	10.0	10.0
41	10.0	10.0
42	10.0	10.0
43	10.0	10.0
44	10.0	10.0
45	10.0	10.0
46	10.0	10.0
47	10.0	10.0
48	10.0	10.0
49	10.0	10.0
50	10.0	10.0
51	10.0	10.0
52	10.0	10.0
53	10.0	10.0
54	10.0	10.0
55	10.0	10.0
56	10.0	10.0
57	10.0	10.0
58	10.0	10.0
59	10.0	10.0
60	10.0	10.0
61	10.0	10.0
62	10.0	10.0
63	10.0	10.0
64	10.0	10.0
65	10.0	10.0
66	10.0	10.0
67	10.0	10.0
68	10.0	10.0
69	10.0	10.0
70	10.0	10.0
71	10.0	10.0
72	10.0	10.0
73	10.0	10.0
74	10.0	10.0
75	10.0	10.0
76	10.0	10.0
77	10.0	10.0
78	10.0	10.0
79	10.0	10.0
80	10.0	10.0
81	10.0	10.0
82	10.0	10.0
83	10.0	10.0
84	10.0	10.0
85	10.0	10.0
86	10.0	10.0
87	10.0	10.0
88	10.0	10.0
89	10.0	10.0
90	10.0	10.0
91	10.0	10.0
92	10.0	10.0
93	10.0	10.0
94	10.0	10.0
95	10.0	10.0
96	10.0	10.0
97	10.0	10.0
98	10.0	10.0
99	10.0	10.0
100	10.0	10.0

Project _____ **Date** _____

Driller _____ Geologist _____

Location

Construction Details

Method of drilling:

Casing type/length:	ft	Diameter	inch
----------------------------	-----------	-----------------	-------------

Screen type/length:	ft	Diameter	inch
1000	1000	1000	1000

Screen slot size:	Screen depth	to
-------------------	--------------	----

Gravel pack:

Well Log

Lithologic Description	From	To	Spoon	Intvl.	Blow Ct.
------------------------	------	----	-------	--------	----------

Comments: Bentonite slurry 17.5-18.5'. Grouted to surface with bentonitic cement. Well 20 is located east of the pond amid several clumps of fill. It appears as if material excavated for the pond was deposited in the area of Well 20 (also Well 21 and 23).

HNu Readings: Instrument was not functioning properly. No readings taken.

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 1

Well Number MW-21 Ground Elevation 585.0
 Project Calumet Containers - IDEM Date 11-11-87
 Driller A. Belasco Geologist R. Funkhouser
 Location 16+30N, 26+00E
T.37N., R.10W., Sec. 24, NW¼

Construction Details

Method of drilling: Hollow Stem Auger
 Casing type/length: PVC / 3 ft Diameter 2 inch
 Screen type/length: Stainless Steel/ 11 ft Diameter 2 inch
 Screen slot size: .010" Screen depth 3' to 14'
 Gravel pack: Pea gravel to 0.5' above screen

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Fill. Black, sandy silt with rootlets.	0	0.5'	None	
Fill. Brown, medium to coarse sand.	0.5'	1.5'		
Fill. Brownish-black medium to coarse sand. Saturated @ 3.5'.	1.5'	4.5'		
Black, sandy silt (appears to be natural).	4.5'	7.5'		
Dark brownish-gray fine sand.	7.5'	15.0'		
Total well depth 15'				
Comments: Bentonite pellets 2.0-2.5'. Grouted to surface with bentonitic cement.				
HNu Readings: Instrument not functioning properly.				

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 1 of 3

Well Number MW-22 Ground Elevation 588.0

Project Calumet Containers - IDEM Date 12-17-87

Driller Fox Drilling, Inc. Geologist R. Funkhouser

Location 12+10N, 21+00E
T.37N., R.10W., Sec. 24, NW $\frac{1}{4}$
Near southernmost corner of site

Construction Details

Method of drilling: Hollow Stem Auger, Rotary Wash, Diamond Core
Barrell
Casing type/length: PVC / 39 ft Diameter 2 inch
Screen type/length: Stainless Steel/11 ft Diameter 2 inch
Screen slot size: .010" Screen depth 39' to 50'
Gravel pack: Fine sand, less than 0.01 inches in diameter.

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
3" snow cover				
Brownish-black sandy silt (fill) Saturation @ 3.5' With wood fragments and small pebbles. Flecks of purple and green noted. 1" of greenish, tarry sludge @ 4'.	0	3.5'	3.0-5.0'	4-5-8
Dark brownish-gray fine sand	3.5'	10'	8.0-10'	3-5-5-
Dark brownish-gray fine sand	10.0'	15'	13.0-15'	5-16-18
HNu @ 15' = 5 ppm	15.0'	20'	18.0-20'	4-9-13
Brownish-gray fine sand				
Brownish-gray fine sand	20.0'	23.9'	23.0-25'	6-10-14
Gray clay, smooth. Appears to be lacustrine.	23.9'	25.0'		
Gray clay, smooth. Lacustrine	25.0'	30.0'	28.0-30'	6-9-10
Hit rock material @ 33.5'. Went to rotary wash drilling at 33.5'. Could not penetrate with split spoon.				

HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD

Page 2 of 3

Well Number MW-22 Ground Elevation _____

Project _____ Date _____

Driller _____ Geologist _____

Location _____

Construction Details

Method of drilling:

Casing type/length: _____ ft Diameter _____ inch

Screen type/length: _____ ft Diameter _____ inch

Screen slot size: _____ Screen depth _____ to _____

Gravel pack: _____

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Wood chips.	33.5'	33.6'		
Gray dolomite interbedded with black shale. Petroliferous odor.	34.0'	37.5'		
Dolomite, siliceous, medium to light gray. Vuggy, many solution modified fractures, fossiliferous.	34.0'	50.0'		
Total well depth 50'.				

HYDROSCIENCE ASSOCIATES, INC.

Test Well Record

Page 3 of 3

Method of Construction: MW-22

1. The hole was augered with hollow-stem auger to 34 ft. at which depth bedrock was hit. A hole was drilled 5 ft. into the bedrock with a 5-7/8 in. bit to a depth of 39 ft. A 4 in. PVC casing was emplaced through the auger string to a depth of 39 ft.
2. Bentonitic cement was poured into the 4 in. casing and it was pulled up and then set back to its original depth, leaving a 5 ft. plug of cement in the bottom of the casing, and a 5 ft. thick annulus of cement between the dolomite and casing. The cement was left to set up before drilling through it.
3. Rotary drilling through the dolomite required an hour per foot. In the interest of saving time, the IDEM allowed the hole for the screen to be drilled with a 3 in. OD diamond core barrell at a rate of 10 ft. per hour.
4. The hole was drilled with the core barrell to a depth of 50 ft. An 11 ft. section of stainless steel screen with a 2 in. PVC riser pipe to the surface was emplaced in the hole between 39 and 50 ft., and packed with fine quartzitic sand larger than .010 in. The sand was brought to 38.5 ft. below the surface and 2 ft. of bentonite pellets were emplaced on top of the sand.
5. The annulus between the 4 in. casing and the hole wall was filled with bentonitic cement to the surface by pouring it through a tremie pipe between the auger and the 4 in. casing as the augers were slowly withdrawn.
6. The annulus between the 2 in. and 4 in. pipes was filled with bentonitic cement to the surface and a steel locking cover was emplaced over the riser pipe.

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 1 of 3

Well Number MW-23 Ground Elevation 585.0
 Project Calumet Containers - IDEM Date 12-22-87
 Driller Fox Drilling Company Geologist D. Leap
 Location 18+00N, 24+50E
T.37N., R.10W., Sec. 24, NW¼

Construction Details

Method of drilling: Hollow Stem Auger, Rotary Wash, Diamond Core
 Casing type/length: PVC-Sched 40-46 ft Diameter ^{Barrell} 2 inch
 Screen type/length: Stainless Steel / 11 ft Diameter 2 inch
 Screen slot size: .010" Screen depth 46' to 57'
 Gravel pack: Fine quartzic sand, smaller than .01" from 44-46'

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Sand, fine, dark, organic.	0	5.0'	3.5' - 5.0'	4-5-9
Sand, fine, gray. Saturation below 0.5'	5.0'	10.0'	8.5' - 10.0'	4-9-17
Sand, fine, gray.	10.0'	15.0'	13.5' - 15.0'	3-5-14
Sand, fine, gray.	15.0'	20.0'	18.5' - 20.0'	4-6-9
Sand, fine, gray.	20.0'	21.0'		
Clay, very smooth, homogeneous brown to tan; difficult to drill.	21.0'	25.0'	23.5' - 25.0'	4-6-8
Clay, same as above.	25.0'	30.0'	28.5' - 30.0'	3-5-6
Clay, same as above.	30.0'	33.0'		
Clay, same as above but darker with numerous limestone chips.	33.0'	35.0'	35.5' - 35.0'	5-7-10
(cont'd.)				

**HYDROSCIENCE ASSOCIATES, INC.
TEST WELL RECORD**

Page 2 of 3

Well Number MW-23 (cont'd.) Ground Elevation _____
 Project _____ Date _____
 Driller _____ Geologist _____
 Location _____

Construction Details

Method of drilling:

Casing type/length: _____ ft Diameter _____ inch

Screen type/length: _____ ft Diameter _____ inch

Screen slot size: _____ Screen depth _____ to _____

Gravel pack: _____

Well Log

Lithologic Description	From	To	Spoon Intvl.	Blow Ct.
Clay, dark to medium brown.	35.0'	38.5'		
Very soft clay.	38.5	39.0'		
Clay, dark brown, very dry and hard. Contained pebbles of dolomite.	39.0'	40.0'	38.5' - 40.0'	35-48-100
<u>Note:</u> At 38.5' changed from auger to rotary bit. Clay was too hard for auger.				
Clay, dry, hard, containing dolomite, pebbles, dark gray.	40.0'	42.0'	No sample recovered.	
Dolomite, siliceous, vuggy, numerous solution-modified fractures, medium to light gray, fossiliferous.	42.0'	57.0'	Continuous core taken.	
HNu Readings: Did not register anything throughout the entire hole.				

HYDROSCIENCE ASSOCIATES, INC.

Test Well Record

Page 3 of 3

Method of Construction - MW23

1. Hollow stem auger 6-1/2 in. ID from 0 to 38.5 ft.
2. Rotary wash, 5-7/8 in. bit from 38.5 to 42 ft.
3. Diamond cored from 42 to 47.5 ft. (this technique had previously been verbally cleared with the IDEM). Core barrell diameter 3 in OD.
4. Reamed with rotary bit 5-7/8 in. diameter from 42 to 44.5 ft. Rock was extremely hard in this location and drilling by both rotary and core methods was extremely slow. IDEM gave permission to set outside casing (4 in. PVC) at 44.5 ft., i.e., 2.5 ft. from bedrock surface, rather than 5 ft. from the bedrock surface as had originally been planned.
5. Four (4) in. PVC Sched 40 casing was set at 44.5 ft. and was cemented into the bedrock by raising the casing 2 ft. off the bottom and pouring in bentonitic cement to a depth of 3 ft. above base. The PVC 4 in. casing was then pushed back down to its base at 44.5 ft. leaving a 3 ft. plug of cement in the casing and a 3 ft. annulus of cement between the outside of the 4 in. casing and the hole wall in the dolomite. The annulus between the 4 in. and the remainder of the hole to the surface was cemented with bentonitic cement. Using a tremie pipe between the PVC 4 in. and the inside of the augers. The augers were slowly withdrawn while the cement was poured in until the entire annulus was cemented in.
6. The next day, December 23, 1987, the remainder of the hole was drilled through the cement plug to a total depth of 57 ft. with the 3 in. core barrell and a continuous core was taken of the bedrock.
7. The 2 in. stainless steel screen was set from 46 to 57 ft. with a 48 ft. 2 in. riser. Fine quartzitic sand was emplaced around it to 2 ft. above the screen top. Bentonite pellets were emplaced for a thickness of 2.5 ft. above the sand from 44 to 41.5 ft.
8. The annulus between the riser and the 4 in. casing was cemented to the surface with bentonitic cement and a locking steel cover was cemented in place over the riser above the surface.

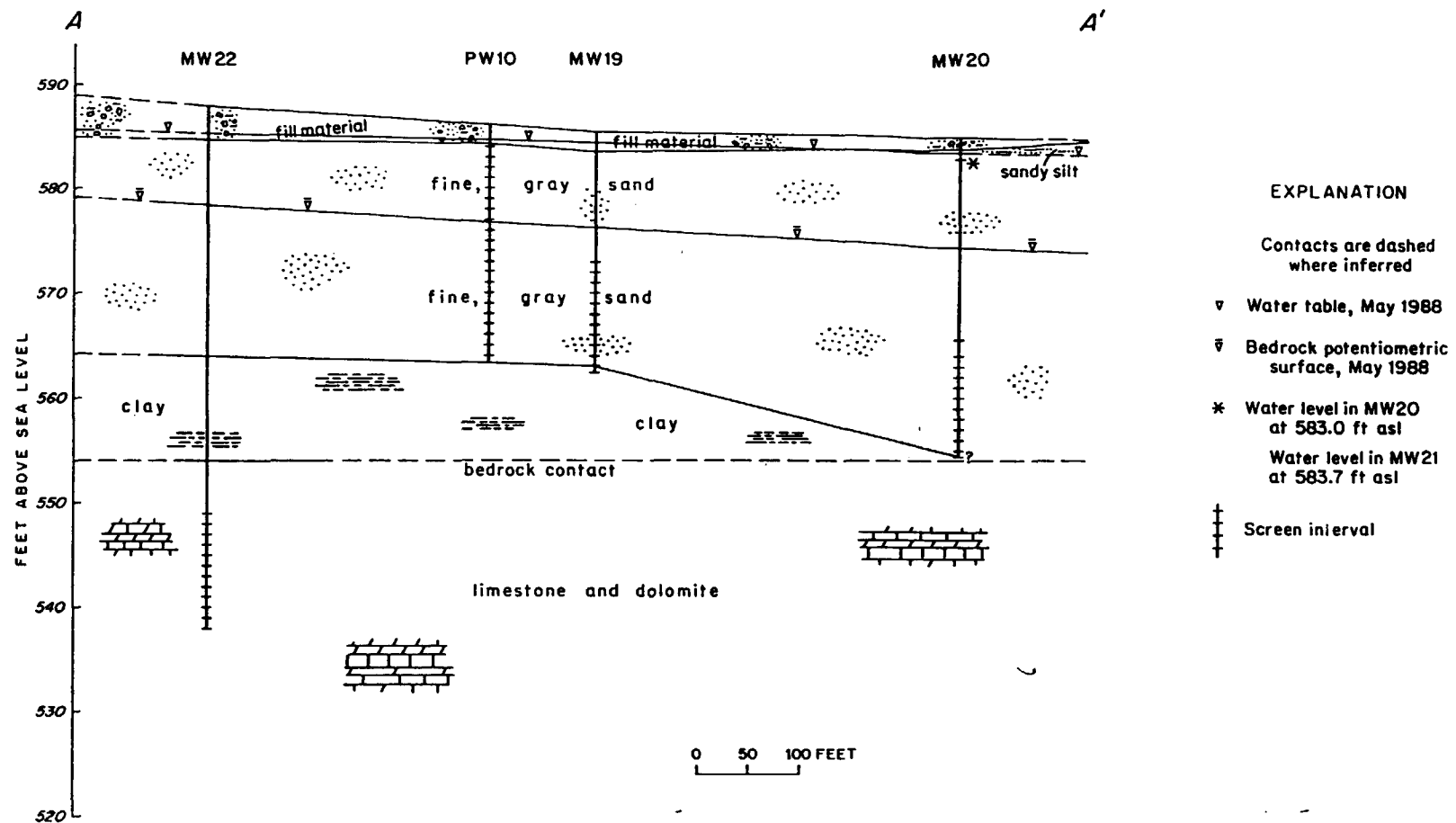


Figure 2.3 Cross section A-A'.

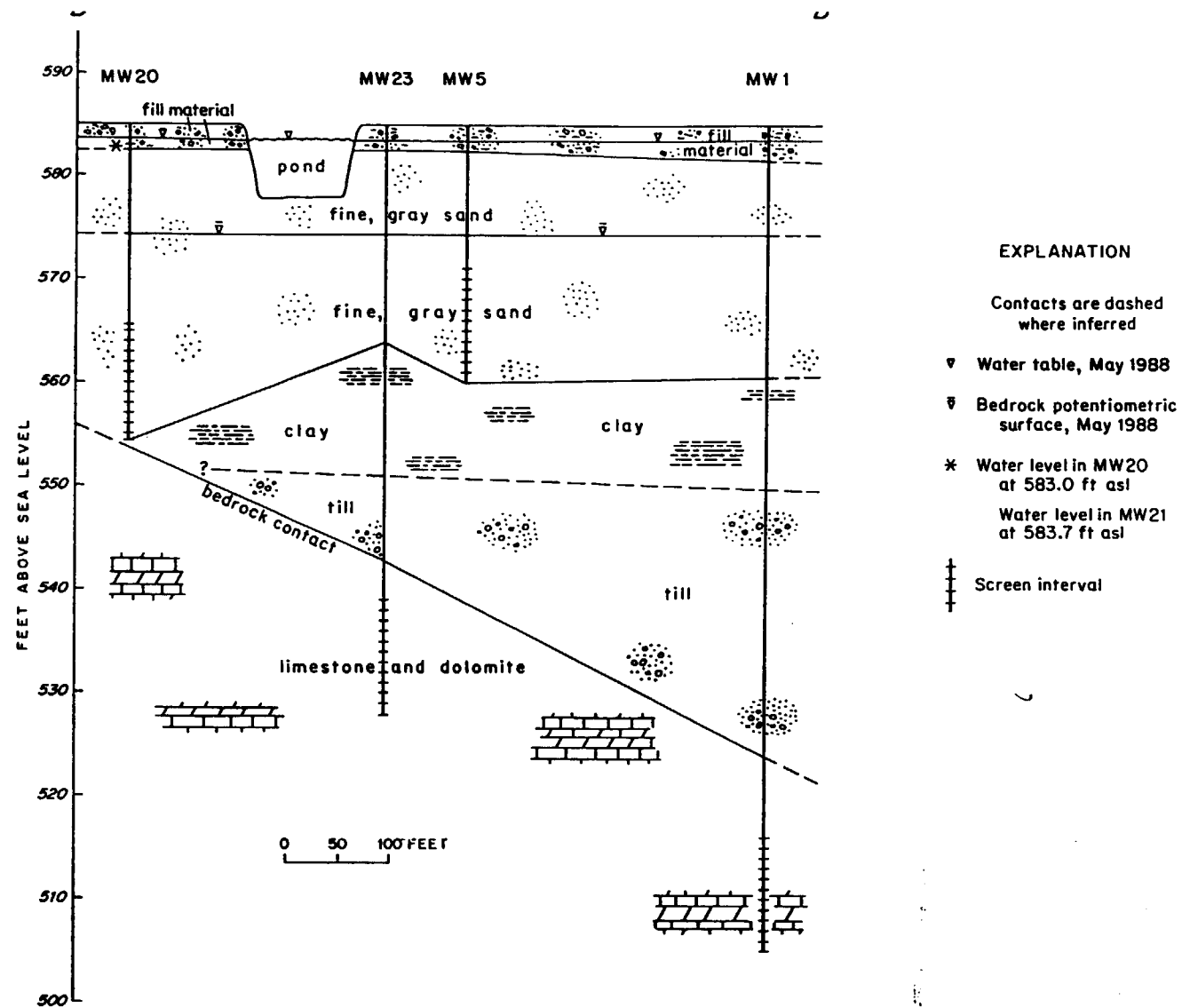


Figure 2.4 Cross section B-B'.

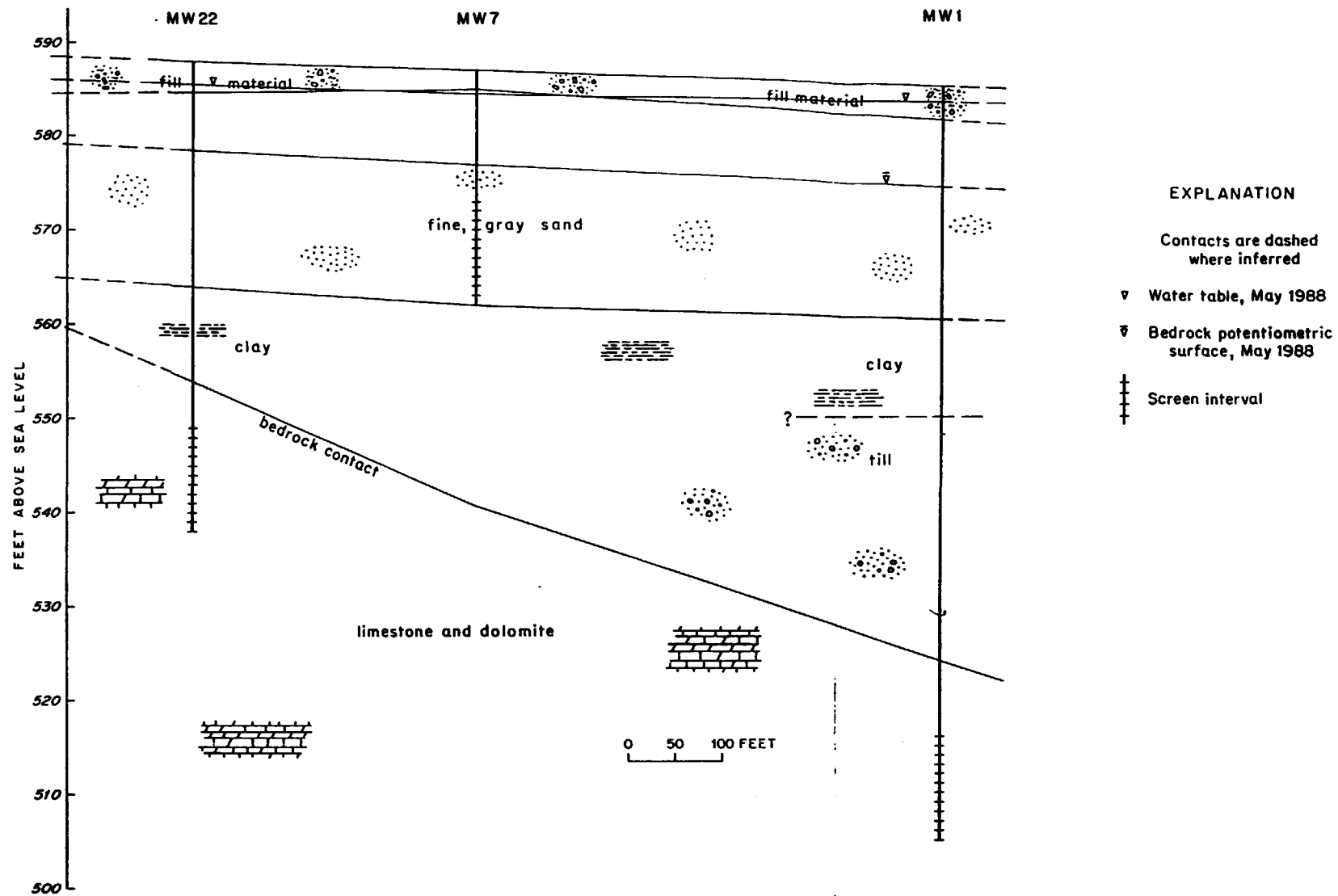


Figure 2.5 Cross section C-C'.